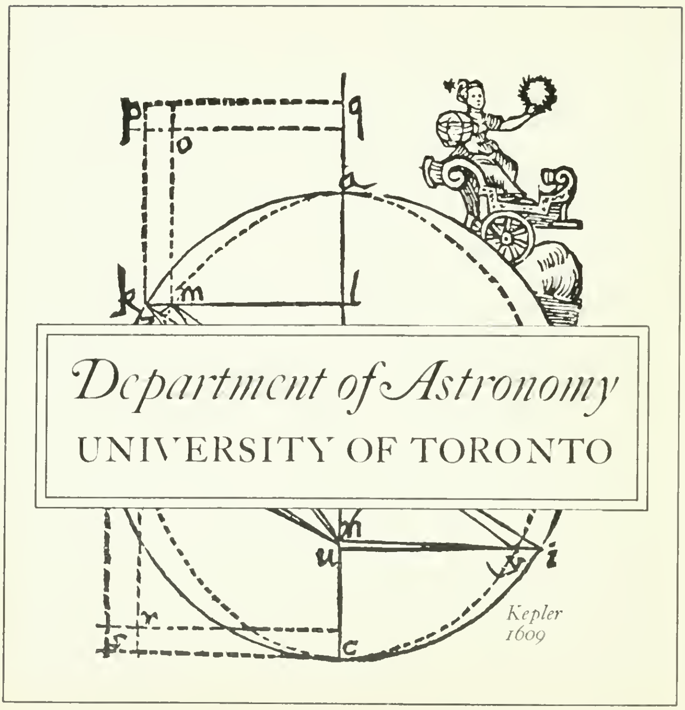
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PERIOD CHANGES OF RR LYRAE VARIABLES IN THE GLOBULAR CLUSTER MESSIER 5

By Christine M. Coutts and Helen Sawyer Hogg

Abstract

The purpose of this investigation is to study period changes in RR Lyrae variables in the globular cluster M5. The study is based mainly on a collection of 167 plates taken between 1936 and 1966 at the David Dunlap Observatory. Some 64 photographs taken by Dr. Harlow Shapley in 1917 with the 60-inch telescope on Mount Wilson have also been measured.

Studies of this type which have been carried out for other globular clusters are briefly discussed. The methods for studying period changes using a phase-shift diagram are explained.

A total of 66 RR Lyrae variables has been studied in M5. Of these, 16 have irregular periods, 18 have been constant, 20 have shown increases (median rate 0.05 ± 0.02 days per million years) and 12 decreases (median 0.075 ± 0.02 days per million years) in period during an interval of about seventy years. It seems not possible at present to attach any evolutionary significance to these changes.

Introduction

Messier 5 is in third place among the globular clusters which are richest in variable stars (ω Centauri and Messier 3 supersede it). The only study of period changes of the RR Lyrae variables in this cluster was made 27 years ago by Oosterhoff (1941), based on observations obtained up to the year 1935. Messier 5 is therefore a cluster very suitable for a study of changes in period. One of us (Sawyer Hogg) has taken a series of 136 photographs of this cluster with the 74-inch telescope between 1936 and 1964 inclusive.

An additional series of 31 plates was taken by Coutts on four nights in 1966 with the 74-inch telescope at the David Dunlap Observatory, after this investigation was begun. Dr. H. W. Babcock kindly lent us some plates taken by Dr. Harlow Shapley with the 60-inch telescope at Mount Wilson Observatory in 1917. Although these plates were studied previously (Shapley 1927), the individual observations were never published and so these plates were remeasured. The measures of the David Dunlap and Mount Wilson plates form the basis for the present investigation.

In addition, a number of published observations of the variables in M5 are available, from 123 photographs taken between 1889 and 1912 by Bailey (1917), and from 81 photographs with the 60-inch Mount

Wilson telescope in 1934 and 1935 by Oosterhoff (1941). When all this material is considered, M5 can be studied over an interval of more than seventy years. It is important to find what characteristics of the period changes of the RR Lyrae variables in M5 are similar to those in the other clusters which have been studied already.

Other Studies of the Period Changes of RR Lyrae Variables in Globular Clusters

About ten globular clusters have been investigated for period changes. The results, on the whole, do not indicate any particular trend in changes in period of the RR Lyrae stars. Some variables have constant periods. Some have periods which are secularly decreasing and others which are secularly increasing. In most clusters, there appears to be no preference for periods to increase or decrease. The clusters which have been investigated specifically for period changes are listed in Table I, in order of decreasing number of variables.

TABLE I

Cluster	No. of RR Lyrae Variables	Investigators
NGC 5272 = M3	173:	Martin (1942) Hett (1942) Belserene (1952) Ozsvath (1957) Szeidl (1965) Kheylo (1966)
NGC 5139 = ω Centauri	140:	Martin (1938) Belserene (1961, 1964)
NGC 5904 = M5	93	Oosterhoff (1941)
NGC 7078 = M15	88	Izsak (1956) Mannino (1956a, 1956b) Grubissich (1956) Nobili (1957) Notni and Oleak (1958) Bronkalla (1959) Fritze (1962) Makarova and Akimova (1965)
NGC 6402 = M14	69:	Sawyer Hogg and Wehlau (1968)
NGC 6121 = M4	41	Wilkens (1964)
NGC 5024 = M53	38:	Margoni (1964, 1965a, 1965b, 1967) Wachmann (1965)
NGC 5466	18	Bartolini, Biolchini and Mannino (1965)
NGC 7089	13	Mantegazza (1961) Kulikov (1961)
NGC 6341 = M92	12	Kheylo (1964, 1965) Bartolini, Battistini and Nasi (1968)
NGC 5053	10	Mannino (1963)

The RR Lyrae stars in ω Centauri exhibit a distinct tendency for the periods to increase. For about 70 per cent of the stars investigated in this cluster, the periods show secular increases while the others decrease, remain constant or fluctuate. The median rate of change of period for 47 variables classed as RR *a, b* types investigated by Belserene (1964) is an increase of 0.11 days per million years.

The RR Lyrae variables in M3, on the other hand, do not exhibit such a tendency. Szeidl (1965) has studied 112 variables. Of these, 22 have periods which are increasing at an average rate of 0.18 days per million years and 25 have periods which are decreasing at an average rate of 0.20 days per million years. Of the other periods, 7 have remained constant and the rest are fluctuating. The average rate of change of period of all the stars is a decrease of 0.02 days per million years, but the median rate is zero. Thus the RR Lyrae variables in M3 behave in a different manner from those in ω Centauri. Belserene (1964) has pointed out, however, that the period-amplitude relations for these two clusters are also different, and therefore she notes that conclusions based on the observations of RR Lyrae variables in one cluster are not necessarily applicable to the class of variables as a whole.

In M15, there are a few more stars with increasing periods than with decreasing, but the tendency to increase is not as marked as that in ω Centauri.

In the other clusters investigated, there are approximately equal numbers of stars with increasing and decreasing periods. Margoni (1967) in his work on M53 has suggested that sine curves can be fitted to the phase-shift diagrams for five of the stars on the basis of the present observations. This implies that the period changes are periodic and if this be true, we can not attach any evolutionary significance to the values of β computed for other stars. The quantity β is the rate of change in the period in days per day as defined by Martin (1938).

For M5, Oosterhoff (1941) used observations from 1895, 1896, 1897, 1912, 1917, 1934 and 1935. He considered 41 stars of RR Lyrae types *a, b* and found that the average period change was an increase of 0.05 days per million years, with 25 periods increasing and 15 decreasing, and 1 remaining constant. The tendency for periods to increase is therefore not as marked as in ω Centauri.

Theory of Investigation of Period Changes

To investigate changes in period among RR Lyrae stars, a reasonably accurate period is needed, i.e., it must satisfy the observations over an interval of one or two years. The light curve is derived by reducing all the observations of the star to one cycle of light variation.

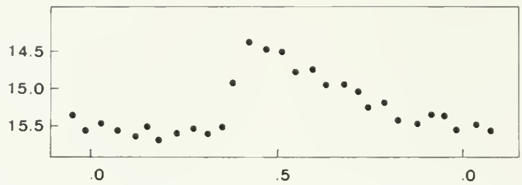

FIG. 1—Light curve of an RR Lyrae variable (phase in fractions of period).

A certain period, P, is assumed and a reference epoch at time E is adopted. All the observations at the different times, t, are reduced to one cycle of period, P, at epoch E, such that: phase $= (t - E)/P$. This is the number of cycles of length P, which have elapsed between epoch E and time t. The phase adopted at time t is the fractional part of this number. When phases are computed at a series of times t, a light curve can then be plotted. If the period is constant and correct, the scatter on the light curve should be that expected from the accuracy of the observations. However, if the scatter is larger than this, the assumed period is incorrect or varying or both. The method used to examine the behaviour of the period is to plot a phase-shift diagram.

There are five cases of the phase-shift diagram, described below.

Case 1: Assumed period incorrect

Suppose that the true period is α, and that an incorrect value P has been assumed in computing the phase for the light curve. Then the resulting displacement in phase is given by:

$$\begin{aligned} \Delta \text{ phase} &= \frac{t-E}{P} - \frac{t-E}{\alpha}, \\ &= (t-E)\left(\frac{\alpha - P}{P\alpha}\right), \\ &\simeq \frac{(t-E)}{P^2} \cdot \Delta P, \end{aligned}$$

where $\Delta P = \alpha - P$.

If Δ phase is plotted against t, a straight line results, and the true period can be determined from the slope of this line, $\Delta P/P^2$.

Case 2: Period changing at a uniform rate

Suppose that the period is not constant, but instead, changes at a constant rate β. If the period at time E is α, then the period at time t is

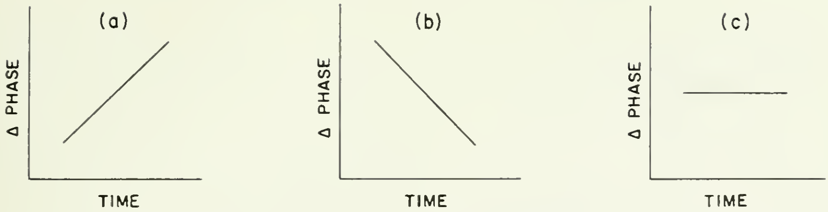

FIG. 2—Phase-shift diagrams for a star of constant period: (a) α, the true period, $>$ P, the assumed period (b) $\alpha < P$, (c) $\alpha = P$.

given by: $P = \alpha + \beta(t - E)$. Since the period is changing at a constant rate, the true phase at time t should be given by:

$$\frac{t - E}{\alpha + \frac{\beta}{2}(t - E)}.$$

The phase calculated assuming a constant period, α, is: $(t - E)/\alpha$. Hence, the displacement in phase (or phase-shift) at time t is:

$$\begin{aligned} \Delta \text{ phase} &= \frac{t - E}{\alpha} - \frac{t - E}{\alpha + \frac{\beta}{2}(t - E)}, \\ &\simeq \frac{t - E}{\alpha}\left[1 - \left\{1 - \frac{\beta}{2\alpha}(t - E)\right\}\right], \\ &= \frac{\beta(t - E)^2}{2\alpha^2}, \end{aligned}$$

where $\frac{\beta}{2\alpha} \cdot (t - E) \ll 1$.

In this case, if Δ phase is plotted against t, the result is a parabola with a vertical axis, with equation:

$$\Delta \text{ phase} = A + Bt + Ct^2,$$

where $C = \beta/2P^2$ day^{-2}. If the parabola is concave upward, β is positive, and the period is increasing. If the parabola is concave downward, the period is decreasing.

Case 3: Assumed period incorrect and period changing at a uniform rate

Suppose that the assumed period is not the true period at time E and that the period is changing at a constant rate. Indeed, if the

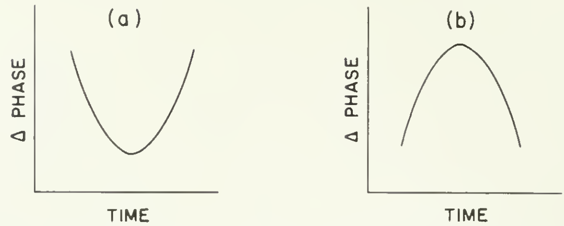

FIG. 3—Phase-shift diagrams for a star with period changing at a uniform rate: (a) $\beta > 0$, period increasing; (b) $\beta < 0$, period decreasing.

period is changing, it is very difficult to determine the period precisely at any given moment. In this case, the phase shift at time t is given by:

$$\begin{aligned}
\Delta \text{ phase} &= \frac{t-E}{P} - \frac{t-E}{\alpha + \frac{\beta}{2}(t-E)}, \\
&= \frac{t-E}{P} - \frac{t-E}{\alpha} - \frac{t-E}{\alpha + \frac{\beta}{2}(t-E)} + \frac{t-E}{\alpha}, \\
&\cong \frac{\Delta P}{P^2}(t-E) + \frac{\beta}{2\alpha^2}(t-E)^2, \\
&\cong \frac{\Delta P}{P^2}(t-E) + \frac{\beta}{2P^2}(t-E)^2.
\end{aligned}$$

Thus, a plot of Δ phase against time once again results in a parabola with a vertical axis (see figure 3). The value of β is again determined from the coefficient of the t^2 term $\beta/2P^2$.

Case 4: An abrupt change in period

If the period changes abruptly, rather than gradually, the phase-shift diagram consists of two straight lines with different slopes. If the

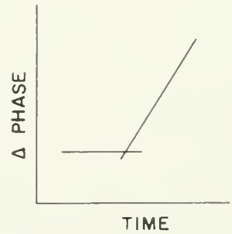

FIG. 4—Phase-shift diagram for a star whose period changes abruptly.

slope of the second line is greater than that of the first, an increase in period is indicated. The amount of change in the period is related to the difference in slope between the two lines: $\Delta P = (\Delta \text{ slope}) P^2$.

Case 5: Irregular changes in period

Many phase-shift diagrams have a more complicated form than those described above. In such cases, it is difficult to predict long-range period changes. An increase in slope indicates an increase in period and a decrease in slope, a decrease in period. However, if these changes occur in an irregular manner, it must be assumed that the period changes are random.

Obviously the phase-shift diagram can give important information regarding the behaviour of the period of a star. In the past, most investigators have assumed a parabolic form for the phase-shift diagram (rather than a more complicated curve) to determine the period change. According to Belserene (1964), β is a useful parameter for describing the extent of the variation in period. She adds, "It is the average rate of period change if the true rate has varied." However, Makarova and Akamova (1965) in a study of RR Lyrae variables of M15 find that for about 50 per cent of the stars they studied, the period changes are abrupt, i.e., the phase-shift diagram is represented better by two intersecting straight lines than by a parabola. This is also a simple assumption, but it is difficult to determine the rate of period change when the observed quantity is its amount.

In the present investigation, the period change is determined by both methods.

Present Investigation

The globular cluster M5 has a total of 98 variables (but the variability of one, no. 51, is questionable). There are two W Virginis variables (nos. 42 and 84), one irregular (no. 50), one SS Cygni (no. 101) and 93 RR Lyrae. Of the RR Lyrae stars, 91 have periods determined (Bailey 1917, Shapley 1927, and Oosterhoff 1941). Sixty-eight are of type *a*, *b* and twenty-three are type *c*.

The plates used with the 74-inch reflector were Eastman Kodak 103aO. Sixty-six RR Lyrae stars (50 of type *a*, *b* and 16 of type *c*) and the two W Virginis stars could be studied on these plates. Most of the stars were measured with a Cuffey iris astrophotometer, but the magnitudes of variables 6, 13, 14, 27, 33, 34, 38, 45, 63, 67, 69, 83 and 98 were estimated by eye.

A sequence of photoelectric *B*, *V* standards determined by Arp

TABLE II

Phase Shifts (in fractions of the period)

Year	No. 1	No. 3	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12	No. 13	No. 15	No. 16	No. 19
1889													
1895–96	−.025	.00	−.01	.01	−.04	.00	−.02	−.01	−.33	.03	.04	−.05	−.04
1897–99	−.06	.00	−.01	−.05	−.04	.00	−.01	.00	−.30	−.03	−.01	−.06	−.03
1901–02	−.04	.00			−.04	.02	−.01	.00		.02?	−.05	−.08	.01
1904–05	−.055	−.01	−.02		−.07	−.01	−.01	−.01		.00?	−.07	−.10	−.04?
1912	−.02?	−.02	.00	.02	−.07	.05?	−.01	.02	−.10	.00	−.20	−.07	−.07?
1917	−.01?	−.04	−.01	−.09	−.07	−.02	−.04	−.01	−.09		−.16?	−.06	−.06
1931	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1936–38	.03?	.00		−.01	.00	−.03	.00	−.02	.00	.00	.00	.04	
1940–42	.03	.01	.03	.06	.05	.00?	.00	−.02	.04	.00	.01	.03	.00
1943–44	.01	.02	.00	.21	.02	.00	.00	.00	.00	.02	.11	.01	.02
1946–49	.00	.01	−.02	.20	.04	.00	.00?	.02	−.01	.05	.19	.06	.04
1950–53	.04	.02	−.02	.21	.11	.01	−.03?	.00	.01		.24	.10	.25
1954–56	.06	.045	−.06	.29?	.14	.05	−.04	.00	−.02	.15	.20?	.11	.44
1959–60	.07	.08	−.05		.15	.03	−.02	.03	−.10	.13	.35?	.16?	.68
1963–64		.08		.38	.17	.03	−.06	.03	−.10		.35?	.16?	1.02
1966	.065	.06	−.07	.53	.25	.02	−.07	.03	−.15	.12	.47	.17	1.09

Year	No. 20	No. 21	No. 27	No. 28	No. 29	No. 30	No. 31	No. 32	No. 33	No. 34	No. 36	No. 38	No. 39
1889													
1895–96	.00	−.04	−.06	−.01	−.19	.00	.01	−.12	−.03	.00	.04?	.03	−.01
1897–99	−.02	−.01	.02	.11	−.10	.05	−.02	−.14	−.04	−.01	.00	.04	.00
1901–02	.01	−.01		.12	−.08?	.01	.06	−.12	−.02	.01			.00
1904–05	−.01	−.03	.06		−.10	.04	.04	−.14	−.02			.03	−.03
1912	.00	−.05	.08	.11	−.09	.00	.01	−.06					.06
1917	.00	−.01		.11	.08?	−.01	−.01	−.08	.00			.62?	−.01
1934	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1936–38	−.01	−.04	.02	−.05	.04	−.02	.03	.00	.00	−.02	−.06?	−.05	
1940–42	−.01	.00		−.06	.09	.00	.00	.01	.00	.09?	.02?	−.09	.00
1943–44	.00	−.01	.17	−.12	.04	.01	−.04	.00	.04	.04	.00?	−.12	.00
1946–49	.01	.00	.25	−.15	−.08	−.01	−.05	.00	.05	.01	−.09?	−.15	.02
1950–53	.00	.00	.20	−.27	−.32	.01	−.05	.04	.06	−.10?	−.06	−.20	.06
1954–56	.02	−.02	.23	−.25	−.40	.01	−.04	.03	.03	.01	.03?	−.29	.07
1959–60	.01	−.01	.26	−.31	−.49?	.00	−.03	.01		.00			.05
1963–64	.01	−.01		−.31		.00	−.03	.01	.16	.00			.05
1966	.01	.00	.29	−.54	−.58	−.02	−.05	.07	.14	.04	−.07	−.55	.07

TABLE II—*continued*

Year	No. 40	No. 41	No. 43	No. 45	No. 47	No. 55	No. 59	No. 61	No. 62	No. 63	No. 64	No. 69	No. 70
1889												-.08	
1895-96	-.01	.02	.00	-.03	-.02	.05	-.02	-.05	-.02	-.03	-.01	-.01	-.07
1897-99	-.04	.01	.01	-.02	-.01	-.01	-.02	.00	-.06	-.02	.00	-.01	-.15?
1901-02	-.01	.03	-.02	-.05	-.05	.00	-.05	-.08	-.15		.00	-.01	-.15
1904-05	.05?	.05	-.04	.01	.05	-.03		-.08	-.27?		.02	.00	-.20?
1912	-.01	.10		-.04	.00	-.04	-.04	-.09	-.25	-.02	.06		
1917	-.05	.02	-.02	-.05	.04	-.05	-.04	-.09	-.04?	-.05	.02	-.01	-.20
1934	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1936-38	.04	-.04	.00	-.05	-.11?	.04	-.04	.02	-.01	.04	.00	.00	.04
1940-42	.02	-.07	.00	-.01	.01?	.05	-.02	.05	.13	.02	-.01	-.08	.14
1943-44	.05	-.07	.01	.04?	.09	.05	-.04	.08	.23	.02	-.07	-.02	.18
1946-49	.11	-.09	.01	.06?	.04?	.09	.01	.14	.33	.05	-.10	-.03	.25
1950-53	.11	-.10	.03	.03	.02	.14	.03	.16	.40		-.12	.00	.33
1954-56	.13	-.12	.02	.03	.01	.16	.02	.23	.35	.10	-.18	-.06	.49
1959-60	.10	-.15?	.05	.00?	-.04	.14	.02		.35			-.05	
1963-64	.10	-.15?	.05	.00?	-.04	.14	.02		.52		-.28	-.05	
1966	.13	-.19	.02	.10	-.08	.14	.01	.33	.51	.12	-.28	-.02	.87

Year	No. 71	No. 73	No. 74	No. 75	No. 76	No. 77	No. 78	No. 79	No. 80	No. 81	No. 83	No. 87	No. 98
1889			-.06						.00				
1895-96	-.01	-.04	-.04	.00	.00	-.02	-.02	-.04	.10	-.05	-.03	.00	
1897-99	-.03	-.06	.01	-.03	-.04	-.01	-.01	-.01	.03	-.02	-.02	.02	
1901-02	-.02?	.03	.08	-.04	.11?	-.09	.00	-.10	.10	.04	.02?	.02	
1904-05			.05			-.04	-.03	-.10		.10	-.01	.01	
1912		-.01			-.02	-.07?	-.02	-.04	.02	.09?	.02	-.01	
1917	-.03	-.05	.01	-.04	-.04	-.10	.00	.03	.10	.09	-.04	-.12?	
1934	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1936-38	.06?	-.03	.01?	-.02	.09	.01	-.04	-.03	-.01	-.05	.00	.05	.02
1940-42	.05	-.09	.01	.02	.01	.02	.00	.10?	.04	-.10	.00	.05	-.05
1943-44	-.04?	-.12	-.03	.00	.02	.00	.00	.08	-.05	-.14	-.05	.04	
1946-49	.08	.00	.01	.05	-.01	.02	.00	.08	-.12	-.16	-.03	.00?	
1950-53	.09	.10	-.08	.07		.08	-.04			-.26	.00	.05	-.09
1954-56	.09	.14	-.12	.02	-.04	.12	-.01	.12		-.34	-.01	.02	-.23
1959-60	.15?	.36		.08	.04	.15	-.01		-.05	-.60	.00	.01?	
1963-64		.36		.08	.04	.15	-.04	.00	-.05	-.60	.00	.01?	
1966	.21	.36	-.19	.06	.22	.16	.02	.07	-.07	-.72	.00	-.04?	-.91

(1962) was used to reduce the data. Arp's B magnitudes were converted to photographic magnitudes by his relations:

$$\begin{aligned} B &= m_{\mathrm{pg}} + 0.23 - 0.16\,CI \\ V &= m_{\mathrm{pv}} \\ CI &= m_{\mathrm{pg}} - m_{\mathrm{pv}}. \end{aligned}$$

In addition, each plate was examined for the visibility of an SS Cygni star discovered by Oosterhoff (1941), but it was not detected. The limiting magnitude of many of the David Dunlap plates, whose exposure times average only 3 minutes, is at a brighter magnitude than the maximum, $m_{\mathrm{pg}} = 17.16$, at which Oosterhoff observed this star. The observations (photographic magnitudes) are listed in Table III where the first column gives the plate number (for variables 1–27), and the second column the heliocentric Julian day with the first two digits (24) omitted. In subsequent sections of the table the plate numbers are not repeated. Measures could be made on 157 plates.

Thirty-three plates taken by Shapley in 1917 with the 60-inch Mount Wilson telescope were also measured. Some of the plates had two exposures of the cluster so that there were 64 photographs altogether, with exposures usually 2 or 3 minutes. All the variable stars except variables 6, 33, and 38 were measured with the iris photometer, while the others were estimated visually. Some of the stars measured on the David Dunlap plates (variables 13, 27, 84 and 98) could not be measured on the Mount Wilson plates owing to the double exposures on the latter. The presence of two exposures on one plate has the effect of crowding the field, particularly in the nuclear region of the cluster. The observations (photographic magnitudes) from the Mount Wilson plates are listed in Table IV. The first column gives the Mount Wilson plate number for the 32 plates whose quality permitted measures, and the second column gives the heliocentric Julian day with the first two digits (24) omitted. From these two columns the plates with two exposures can be identified. We made every effort to determine which exposure was made first, but we cannot guarantee that the decision is always correct. The time difference between the two exposures is so small that we used the means of the times and of the magnitudes.

On both series of plates, no correction was made for background light which has the effect of making the stars in dense regions of the cluster appear too bright. There are no photoelectric standards in these regions, and correction for background intensity without such standards could introduce additional uncertainties into the results.

These two series, totalling 200 plates, along with the values from 123

TABLE III

Photographic Magnitudes from the David Dunlap Plates

TABLE III. PHOTOGRAPHIC MAGNITUDES FR

Plate	Julian Day	No. 1	No. 2	No. 3	No. 6	No. 7	No. 8	No. 9	No.
819	28308.736								
828	8309.651								
829	.661	15.3	15.17	14.74	15.05	15.3	15.6	14.80	14.9
830	.670	15.25	15.19	14.76	15.0	15.0:	15.48	14.89	14.8
831	.677	15.28	15.29	14.86	14.85	14.96	15.42	14.97	14.6
838	.796		15.43	15.11	14.85	14.76	14.65	15.18	15.1
1107	8365.608	15.45	15.43	15.17	15.25	14.53	15.20	15.02	15.3
1122	8366.608	15.4	15.39	15.39	14.9	14.66	14.76	15.36	15.2
1285	8399.596	15.39	14.81	15.38	14.85	15.56	15.40	15.36	15.2
1976	8688.640				14.6				
1990	8689.640								
2005	8692.632	15.3	15.48	14.97	14.9	15.35	15.35	14.82	15.5
2012	8693.730	15.4	15.5?	15.21	14.85	15.45	15.35	15.31	15.5
2029	8696.631	14.55	14.77	15.51	15.05	15.50	15.21	15.54	15.1
2108	8715.638								
3246	9071.660	15.47	15.51	15.41	14.5	14.78	15.43	15.3	15.6
3259	9072.698	15.42	15.47	15.3	15.05	15.27	15.44	15.25	15.4
3269	9073.605	15.34	15.23	15.33	15.05	14.74	15.3	15.01	15.5
3284	9076.603				14.6:				
3296	9077.600								
3310	9078.600								
3325	9079.602	14.68	15.42	15.31	15.15:		15.21	15.45	15.6
5706	9786.609	14.56	15.5	15.45	15.25	15.01	15.51	15.27	15.1
5720	9787.608	15.45	15.62	15.43	15.25	15.12	15.54	15.63	14.4
5804	9813.610	15.4	15.58	15.45	15.25	15.43	14.95	14.65	14.5
5817	9814.612	15.41		15.45	15.3	15.31	15.13	15.36	15.3
5832	9815.613	15.48	15.47	15.05	15.15	15.01	15.56	15.36	15.5
5839	9816.611	15.44	15.44	15.44	14.85	14.75	15.5	15.23	15.4
6855	30171.617	15.52	15.6	15.21	14.6	14.4	15.5	15.1	15.6
6868	0172.615	15.44	15.58	14.96	14.5	14.41	15.4	15.39	15.5
7852	0519.606	15.53	15.25	14.84	14.9	15.40	15.28	14.74	15.5
7867	0520.606	15.41	15.58	15.39	14.55	15.41	15.42	15.37	15.3
7935	0550.608	14.97	15.37	15.47	15.25	15.37	15.23	15.44	15.5
7952	0553.604	15.06	15.4	15.41	14.85	15.43	15.5	15.49	15.7
7971	0554.614	15.32	15.81	15.15	14.4	15.66	15.75	15.27	15.1
7989	0555.629	15.39	15.44	14.92			15.56	15.45	15.2
8008	0556.620	15.39	15.21	15.45	15.25	15.45	15.40	14.87	14.9
8115	0586.572	14.75	15.02	15.3	15.0	15.28	15.05	14.56	15.3
8801	0880.592								
8804	.623	15.49	15.53	15.43	14.4	14.57	15.5	15.42	15.5
8807	.659	15.22	15.54	15.33	14.6	14.55	15.43	15.27	15.
8810	.690	15.4		15.36	14.85	15.0	15.49	15.45	15.
8813	.730	15.36	14.15	15.43	14.9	14.92	15.50	15.35	14.
8816	.760	15.1	14.46	15.44	14.95	15.11	15.55	15.0	14.
8819	.788								
8827	0883.593								
8830	.630	15.29	15.54	15.31	15.1	14.71	14.67	14.55	15.
8833	.664	15.47	15.66	15.41	15.25	15.05	14.9	14.74	15.
8836	0884.622								
8839	.651								
8842	.680	15.41	15.64	15.35	15.25	15.19	14.80	15.32	15.

THE DAVID DUNLAP PLATES

No. 11	No. 12	No. 13	No. 14	No. 15	No. 16	No. 18	No. 19	No. 20	No. 21	No. 25	No. 27
		14.55	15.45								
		15.15	15.25								15.5
15.24	15.62	15.1	15.2	15.38	14.97	14.65	15.6	15.35	15.6	14.66	
15.22:	15.42	15.05	15.2	15.3	14.94	14.68:	15.51	15.24	15.49	14.61	15.6
15.24	15.35	15.0	15.3	15.33	14.96	14.91:	15.44	15.29	15.48:	14.61	15.5
15.37	15.55	14.6	15.4	14.97	15.04	15.17:	15.52	15.34	14.58	14.22	14.85
15.31	14.85	15.15	14.85	15.31	15.12	15.47:	15.54	15.16	15.28	15.28	15.6
14.88	15.19	14.85	14.95	15.28	15.0	15.31:	15.50	14.67	15.16	14.21	15.55
15.31	15.44	14.25	15.1	15.35	15.23	15.15	15.46	14.94	15.34	14.41	15.2
			15.0:								
15.18	15.30	14.65	15.3	15.17	15.28:	15.06	15.24	15.35	15.44	14.74	15.35
14.94	15.50	14.8	15.25	15.01	15.13	15.31	15.55	15.40	15.40	14.77	14.85
14.35	15.61	15.0	15.35	15.43	14.12	14.97	15.64	15.32	15.53	14.63	15.4
15.3	15.52	15.05	15.0	15.05	14.4	14.56	15.51	15.32:	15.44	14.56	15.55
14.88	15.31	15.1	15.2	15.22	15.34	15.32	14.91	15.35	15.23	14.80	14.35
15.46		14.85	14.9	15.08	14.51	15.34	14.77	14.82	15.49	14.38	15.65
			14.9	15.1							
			15.25								15.3:
15.32	15.44	14.95	15.3		15.04	14.88	15.35	15.34	15.48	14.12	15.5
14.93	15.36	14.9	15.25	15.08	14.14	15.18	14.92	15.35	15.40	14.4	15.55
15.57	15.63	14.45	15.3	15.0	15.2	15.31	15.28	15.33	14.81	14.27	14.8
15.37:	14.38		14.6?	15.25	15.24	15.34	15.54	14.90	14.75	14.59	15.2
14.82	15.04	15.2	15.3	15.3	14.98	15.57:	15.53	15.25	15.69	14.66	15.3
15.48	15.34	14.95	15.35	15.17	15.46	14.98	15.65	15.30	15.39	14.64	15.45
15.38	15.54	14.95	15.45	15.15	15.21	14.77	14.64	14.83	14.65	14.65	
15.25	15.5	15.0	14.95	15.27	15.3	14.50	15.38	15.35	15.12	14.71	15.0
14.37	15.57	14.95	14.95	15.29	14.35	14.92	15.54	15.02	15.45	14.67	15.55
15.17	15.57	15.3	15.25	14.93	15.16	14.45	15.24	15.33	14.75	14.58	14.95
14.51	15.71	14.95	15.5	15.16	14.99	14.97	14.41	14.99	15.56	14.66	15.5
15.17	15.34		15.55	15.08	15.28	14.97	15.48	15.11	15.47	14.51	14.85
15.26	15.02	15.25	14.75	15.16	14.85	15.11	14.88	14.98	15.42	14.48	15.3
14.26	15.52	15.4	14.9	15.21	13.82	15.56	15.56	14.93	14.84	14.16	15.7
15.38	15.56	15.35	15.2	15.20	14.69	15.26	15.72	15.33	15.58	14.39	15.2
15.23	15.64	15.3	15.0	15.30	13.97	15.03	15.72	14.92	15.36	14.39	14.9
15.67	15.51	14.8	15.35	15.25	14.85	15.22	15.28	15.2	15.06	14.63	15.6
		14.8	14.6								15.4
14.69	15.44	14.9	14.8	15.04	14.87	15.05	14.44	15.45	14.56	14.43	14.85
14.70	15.4	14.85	14.8	14.90	14.73	15.09	14.81	15.07:	14.83	14.15	14.75
14.95	15.6	14.85	14.9	15.00	14.89	15.10	15.1	14.88	14.95	13.87	14.75
14.94	15.47	14.9	15.25	14.92	14.91	15.10	15.3	14.42	15.09	14.0	14.95
15.18	15.54	14.9	15.25	15.06	15.08	15.20	15.4	14.65	15.29	14.26	15.1
		14.95	14.95								
14.80	15.49	14.5	15.2	15.19	13.85	15.20	15.46	15.38	14.50	14.57	14.95
15.02	15.62	14.65	15.25	15.08	14.05	15.26	15.56	15.54	14.76	14.54	15.25
		14.6	15.15								15.3
			15.2								
14.80	14.44	14.75	15.3	15.05	15.25	14.95	15.55	15.34	15.55	14.43	15.55

Plate	Julian Day	No. 1	No. 2	No. 3	No. 6	No. 7	No. 8	No. 9	No. 10
8846	30884.721	15.43	15.60	15.47	14.95	15.41	14.85	15.47	15.55
8851	.771		15.58	15.26	14.95	15.41	14.99	15.26	15.44
8887	0899.602	14.62	15.50	15.22	15.25	15.21	15.17	15.48	15.72
8891	.647	14.8	15.21	15.17	14.95	15.38	15.37	14.85	15.55
8897	.701	15.16	14.73	15.37	15.05	15.55	15.59	14.58	15.69
8912	0900.604	14.76	15.38	15.25		15.45	14.9	15.22	15.50
8916	.638	14.62:	15.5	14.98	14.95:	15.4	15.15	15.18	15.50
8935	0901.632								
8938	.676	14.55	15.77	15.44	15.05	15.44	15.01	15.42	15.42
9001	0932.604	15.24	15.54	15.03	15.05	15.16	15.55	14.66	15.63
9021	0933.589	14.97			15.05	14.85			
10098	1257.634	14.93:	14.50	15.51	14.35	15.23	15.45	14.86	15.29
10108	1258.625								
10121	1259.604	14.55	15.74	14.77	15.05	15.42	15.2	14.62	15.16
12043	1969.736	14.52	15.21	15.17	15.25	14.16	15.34	14.72	15.15
12063	1970.698								
12109	1976.641	14.93	15.28	15.42	14.45	14.26	14.74	14.74	14.96
12138	1977.690	14.93	15.26	15.49	14.75	14.65	14.55	15.33	14.75
12276	2000.641	15.07	15.55	15.37	15.15	15.35	14.6	15.1	15.40
12323	2004.652	15.63	15.57	15.38	14.95	15.41	15.37	14.55	15.09
12357	2006.599	15.31	14.62	15.27			15.33	15.72	15.23
13326	2326.715	14.46	15.52	14.53	14.9	14.27	14.96	15.47	15.60
13340	2328.739	14.51	15.21	15.82	15.25	14.5	15.55	15.46	15.54
13392	2354.604	15.54	15.62	15.48	15.15	15.65	15.03	15.63	15.46
13415	2355.607	15.37	15.51	14.96	15.25	15.12	15.77	14.9	14.84
13439	2356.605	15.26	15.63	15.32	15.2	15.25	15.25	15.15	14.86
13454	2357.604	15.29	15.17	15.9	14.95	15.36	15.50	14.67	14.51
13504	2361.704	14.84	15.15	15.23	15.05	15.3	14.75	15.18	15.41
14506	2733.605				15.15				
14530	2734.604	15.5	15.16	15.5		14.02	15.55	15.35	15.57
14578	2740.608	15.28	15.08	15.41	14.55	14.48	15.52	14.65	15.14
14602	2741.607	14.97	15.37	15.18	15.05	15.08	15.7	15.40	15.53
14627	2742.648	14.81	15.25	14.65	15.3	15.02	15.46	14.70	15.6
14750	2770.576	15.49	15.44	15.42	15.4	15.48		14.94	15.28
16016	3068.668	14.37	15.35	15.1	15.35	15.35	15.16	15.23	14.48
16043	3069.654	15.21	15.11	15.37	15.5	15.44	14.57	15.52	15.48
16167	3095.604	15.35	15.77	14.91	15.45	15.25	15.77	14.57	15.17
16196	3096.609	15.54	15.52	15.48	15.45	15.01	15.35	15.34	15.78
17448	3476.602	15.7	15.49	15.03			14.8	14.79	15.28
17472	3477.601	15.38	15.49	15.45	15.25:	15.63	15.7	15.45	15.37
17504	3481.597	15.26	15.0	14.99		14.1	14.98	15.03	15.11
17627	3505.572	15.35	15.6	15.18	15.25	15.3	14.81	15.47	15.23
18162	3823.649	14.5	15.31	14.9		15.0	15.35	15.41	15.65
18273	3858.636	14.3	15.68	15.3	14.7	15.26	15.59	15.42	15.50
18277	3859.590								
18292	3860.589	15.39	15.16	15.44	15.25	15.17:	14.60	15.35	15.34
19147	4180.634	14.76	15.4	15.04	14.9	15.64	14.82	15.36	15.37
19164	4181.607	14.51	15.04	15.54	15.25	15.61	15.71	15.49	
19186	4182.607	15.51	14.98	15.18	15.25	15.37	15.58	15.25	14.82
19191	4183.608								
20072	4538.633	14.87	15.62	15.3	14.85	14.00	15.37	15.4	14.59
20092	4539.634	14.65	15.53	14.83	14.55	14.09	15.15	14.85	14.65

No. 11	No. 12	No. 13	No. 14	No. 15	No. 16	No. 18	No. 19	No. 20	No. 21	No. 25	No. 27
14.21	14.98	14.85	15.55	15.11	15.58	15.05	15.66	15.39	15.66	14.21	15.3
14.58	15.22	14.8	15.3	14.94	15.18	15.0	15.48	15.38	15.35	14.05	15.4
14.2	14.58	15.0	14.5	15.10	15.22	14.97	15.58	14.55	15.41	14.56	15.25
14.3	14.44	14.85	14.8	15.10	15.13	15.04	15.65	14.58	15.40	14.48	15.15
14.66	14.94	15.2	15.0	15.39	15.41	15.25	15.83	14.82	15.62	15.62	15.3
15.06:	14.75	14.8	14.65	15.05	14.68	15.0	15.71	15.3	14.86	14.42	
15.41	15.04	14.65	14.8	15.12	14.79	15.26	15.54	15.3	14.95	14.67	15.2
15.35	15.45	14.95	15.25	15.21	15.42	15.32	15.65	15.35	15.67	14.67	15.5
15.29	15.86	14.95	15.6	14.68	15.15	15.17	15.82	14.67	14.55	14.29	15.3
14.1		14.95	15.5		14.20					13.97	15.6
15.45	15.53	15.2		15.12	14.89	14.56	15.19	15.12	15.27	14.52	15.25
14.71	15.66	15.25	15.5	14.89	15.07	15.16	15.48	15.45	15.32	14.56	15.5
15.35	14.30	15.25	14.6	15.06	13.78	15.31	15.6	15.39	15.58	14.45	15.5
			14.4								
15.24	15.63	14.7	15.2	15.17	15.06	15.27	15.01	14.77	14.79	14.52	15.2
14.7	14.18	15.0	15.4	15.4	14.81	15.52	15.63	15.49	15.59	14.45	15.45
15.44	14.37	15.25	15.5	15.31	15.25	15.11	15.16	15.31	15.46	14.7	15.3
15.30	15.7	15.2	15.4	15.4	14.40	15.64	15.75	14.62	15.20	14.53	15.5
	15.81	15.4	15.5	14.95	14.32:	14.32:	15.55		15.25	14.43	15.15
15.26	15.02	14.85	15.0	14.90	14.38	15.24	14.48	15.27	15.50	14.35	15.6
14.95	15.51	15.25	14.95	14.96	14.75	14.96	15.54	15.41	14.61	14.35	15.45
15.59	15.74	15.1	14.45	15.33	14.9	15.05	15.63	15.1	15.82	14.48	15.6
15.27	14.17	15.4	14.85	15.36	15.16	14.64	15.87	15.00	15.42	14.48	14.9
14.53	14.86	15.3	14.8	15.1	14.77	14.93	15.40	15.51	14.59	14.28	14.55
15.30	15.21	15.3	14.95	15.35	15.22	15.1	15.61	14.92	15.51	14.29	15.0
15.35	14.40	15.3	15.5	15.02	14.67	14.99	15.56	15.13	15.40	14.64	15.55
		14.95	14.4								15.6
15.48	15.38	14.95	14.6	14.92	13.97	15.29	14.63	15.59	14.63	13.84	15.15
15.39	14.83	14.55	15.2	14.84	14.69	15.23	15.56	15.26	15.02	13.75	15.55
14.72	15.42	14.9	15.25	15.01	15.25	15.60	15.86	15.12	15.56	14.33	15.5
15.33	15.7	14.75	15.25	14.79	14.71	14.49	14.60	14.66	15.17	13.57	15.6
15.36	15.12	15.15	15.2	14.87	15.20	14.98	15.52	15.49	15.46	14.19	15.15
14.17	15.50	15.15	15.5	14.93	15.01	15.35	15.60	15.30	15.24	14.51	14.55
15.26	15.62	14.85	15.45	14.79	14.58	15.44	15.78	15.28	15.39	14.34	14.75
14.8	14.93		14.8	14.9	14.73	15.68	14.75	14.74	15.65	14.65	15.25
15.35	15.18	15.25	14.9	14.96	14.01	15.38	15.09	15.34	15.48	14.51	15.6
	15.46		14.85	15.2			15.60		15.51	14.06	
15.14	15.67	14.9	14.75	15.31	14.76	15.59	15.43	15.50	15.30	14.1	15.6
14.34	15.46		15.1?	14.91	14.76	14.65	15.27	15.25	15.07	14.18	
14.94	15.58		15.25	15.32	15.14	14.96	15.5	15.43	15.60	14.40	14.6
14.07	15.59		15.5	14.85	14.7	14.75	15.17	15.24	15.41	14.07	
15.26	15.70	15.3	15.3	15.01	14.75	14.92	15.74	14.47	15.07	14.42	15.6
14.2	15.62		15.4	15.44	15.06	14.83	15.57	15.09	15.44	14.68	
14.32	14.32	14.9	15.35	14.98	15.31	15.57	15.63	15.25	15.42	14.73	15.5
15.49	14.69	15.05	15.55	15.16	15.11	15.59	15.78	14.7	15.09	14.58	15.6
15.31	15.13	14.9	15.2	15.04	14.91	15.27	14.48	15.35	15.62	14.33	15.5
			15.2								
15.39	15.51	14.7	14.85	14.86	14.89	14.95	15.59	15.11	15.35	14.33	
15.33	15.59	14.9	15.2	14.88	14.30	15.11	15.67	15.11	14.69	14.33	15.7

Plate	Julian Day	No. 1	No. 2	No. 3	No. 6	No. 7	No. 8	No. 9	No. 10
20110	34540.613	14.33	15.49	15.37	15.25	14.20	14.67	15.44	15.53
20227	4572.602	15.09	14.96	14.81	14.6	15.05	15.49	15.32	14.94:
20240	4573.635	15.1	14.85	15.3	14.65	15.15	15.37	15.38	14.51
20255	4574.602	14.5	15.6	15.25	15.3	16.0	15.69	15.17:	15.17
20274	4575.603	14.43	15.58	14.7	15.25	15.48	14.76	15.46	15.26
21394	4929.623	15.33	15.80	15.38		15.61	14.82	14.74	15.55
22336	5273.612	15.44	14.82	14.69	14.9	14.69	15.6	15.11	14.72
22356	5274.609	15.51	14.61	15.42	14.85	15.29	15.53	15.48	14.46
22373	5275.610	15.16	15.86	14.91	14.5	15.15	15.69	14.85	15.22
22470	5307.600	15.10	15.62	15.38	15.0	15.13	14.91	14.81	14.98
22491	5308.599	15.5	15.65	15.24	14.7	15.07	14.8	15.26	14.56
22514	5309.600	15.54	15.7	14.92	14.95	15.39	15.57	15.55	15.36
22538	5310.600	15.49	15.52	15.38	15.0	15.31	15.6	14.99	15.54
23203	5658.601		15.56		15.0				
23215	5661.602	15.27	14.93	15.5	15.05	15.12		15.56	14.98
23293	5685.588	15.08	15.08	15.26	14.65	15.44	14.92	15.44	15.6
23313	5687.592	14.63	15.85	15.30	15.4	15.06	15.52	15.28	14.81
23327	5688.590	14.55	15.52	15.31	15.25	14.65	15.55	14.72	14.76
24782	6752.607	14.87	15.48	15.01	14.8	14.46	15.68	15.31	14.85
24803	6753.602	14.55	15.63	15.16	14.7	14.59	15.52	14.78	14.02
25182	7113.610	14.62	15.57	15.4	14.95	14.92	15.52	14.61	15.52
25209	7115.636	14.23	15.43	14.83	15.1	15.15	14.91	14.75	15.29
25231	7116.640	15.10	15.30	15.34		15.23	14.78	15.15	15.02
26824	8198.614	15.37	14.96	15.3	15.2	15.44	15.43	15.33	15.11
26845	8199.629	15.29	15.35	15.02			15.5	14.70	14.53
27544	8584.628	15.28	15.38	15.35	15.1	15.25	15.42	15.43	15.37
27551	8586.605	14.92	15.53	15.15	15.05	15.47	14.82	15.44	15.1
29082	9262.772								
29083	.779	14.42	14.72	15.28		14.82	14.75	14.85	15.48
29084	.785	14.38	14.91	15.41	15.25	15.15	14.49	14.95	15.61
29087	9265.585				14.75				
29092	.620								
29097	.680	15.15	15.7	15.2		13.95?	15.27	15.05	14.88
29098	.684								
29099	.772	15.27	15.60	15.31		14.44?	15.41	15.22	14.92
29103	.816	15.4	15.47	15.31	15.05	15.31	15.61	15.28	14.95
29104	.819	15.65	15.63	15.43	14.9	15.24	15.38	15.31	15.11
29106	.847	15.53	15.34	15.50	14.95	15.47	15.65	15.39	15.30
29138	9270.772	15.10	15.35	15.30	15.05	15.2	15.49	15.27	15.44
29139	.776	15.22	15.35	15.31		15.35	15.42	15.28	15.58
29141	.798	15.03	15.62	14.93	15.25	15.36	15.43	15.27	15.45
29142	.803	15.28	15.6	14.96		15.26	15.5	15.31	15.56
29148	9271.615	15.11	15.56	15.11	14.95	14.71	14.83	15.32	15.00
29149	.619	15.02	15.66	15.16	14.8	14.84	14.90	15.5	14.91
29151	.647	14.43	15.27	15.12	14.6	14.82	14.97	15.38	15.00
29152	.651	14.49	15.07	15.27	14.55	14.88	14.98	15.49	15.00
29155	.697	14.33	14.79	15.15	14.65	15.12	15.06	14.92	14.92
29156	.701	14.60	14.60	15.44	14.6	15.05	15.22	14.88	15.20
29158	.722	14.72	14.72	15.34	14.9	15.16	15.3	14.91	15.18
29159	.725	14.82	14.81	15.38	14.65	15.22	15.24	14.72	15.44
29164	.771	15.08	15.14	15.34	15.1	15.48	15.41	14.51	15.48
29165	.776				14.9				
29169	.817	15.10	15.23	15.27	14.95	15.48	15.5	14.69	15.36
29170	.820	15.07	15.32	15.35		15.37	15.45	14.76	15.45

No. 11	No. 12	No. 13	No. 14	No. 15	No. 16	No. 18	No. 19	No. 20	No. 21	No. 25	No. 27
14.51	15.5	15.25	15.25	14.95	14.84	15.30	15.80	14.53	15.57	14.47	15.8
15.63	14.69	14.95	14.85	15.18	14.20	15.11	15.52	15.5	15.33	14.37	15.6
15.55	15.2	14.95	14.75	15.06	15.03	15.03	14.37	14.93	15.17	14.48	14.6
14.82	15.7	14.95	14.7	15.28	14.49	15.55	15.00		15.78	14.78	14.85
15.4	15.79	14.9	14.85	15.08	15.11	14.8	15.15	15.16	15.46	14.51	15.15
14.12	15.69	14.65	14.5	14.68	14.49	14.83	15.59	15.09	15.52	14.39	
15.03	15.63	14.95	14.65	15.31	15.20	14.68	15.45	15.53	15.32	14.58	15.4
14.94	14.32	15.15	14.65	15.25	14.14	15.05	15.76	14.98	14.90	14.48	15.6
14.98	14.87	14.95	14.55	15.28	14.72	15.09	15.70	15.20	15.46	14.21	15.5
14.96	15.63	15.2	15.5	15.24	13.88	15.15	15.65	15.23	15.55	14.59	15.6
14.48	15.64		15.2	15.2	14.81	15.24	15.49	14.59	15.20	14.5	
15.65	15.9	15.15	15.6	15.2	14.16	15.39	15.00	15.50	14.95	14.5	15.6
15.21	14.23	15.15	15.4	15.14	15.12	15.49	14.51	15.19	15.41	14.37	14.95
			14.95							14.24	
15.22	15.33	15.2	15.3	15.58	15.22	15.09		14.89	15.66	14.51	15.25
15.29	15.77	14.8	15.5	15.01	14.92	15.39	14.97	15.34	15.43	14.26	15.3
14.07	14.3	14.85	15.65	15.02	14.75	14.81	15.0	15.59	15.55	14.06	15.4
15.19	14.82	14.9	15.6	15.21	14.49	15.07	15.38	15.27	15.4	14.06	
14.75	14.61	14.95	15.0	15.04	14.13	15.24	15.16	15.09	15.16	14.48	15.4
15.46	15.07	15.15	15.0	14.95	14.77	14.29	15.41	14.99	14.85	14.55	14.2
14.23	14.73	15.0	14.65	15.15	15.23	14.68	15.36	15.34	15.32	14.42	15.6
15.4	15.27	14.95	14.7	15.1	15.26	15.18	15.45	14.80	15.48	14.41	15.25
14.59	15.57	14.85	14.8	15.08	14.84	15.18	15.58	15.55	15.21	14.89:	
15.5	15.48	15.4	14.8	14.81	13.75	15.06	15.51	15.49	14.60	14.42	15.6
15.32	14.81		14.9	14.83	14.76	14.96	14.55	15.35	15.38	14.35	
15.36	14.82	14.8	15.35	15.17	14.26	15.23	15.21	14.97	15.02	14.36	14.95
14.98	15.43		15.2	15.15	14.41	15.45	15.33	15.5	15.34	14.45	
15.35	14.48			14.8	14.58	15.15:	14.88	15.05	15.1	14.42	
15.55	14.45	15.25	15.5	14.9	14.65	15.29	14.89	15.27	15.17	14.31	14.8
			14.7								
			15.0								
14.8	15.12		15.35	15.35	14.88	15.38	15.34	15.13	14.65	14.54	
15.41	15.43:		15.6	14.84	15.22	15.03:	15.45	15.32	15.01	14.05	
15.42	15.60	15.15	15.65	14.93	15.22	14.77	15.67	15.37	15.17	14.25	15.5
15.63	15.72	15.25	15.5	14.93	15.35	14.65	15.47	15.6	15.15	14.18	15.25?
15.7	15.73	15.3	15.6	15.07	15.13	14.97	15.78	15.17	15.29	14.30	15.6
14.36	14.87	14.8	15.55	15.09	14.82	15.34	14.93	14.48	15.28	14.25	14.8
14.54	14.98		15.5	15.0	15.05	15.17	14.89	14.46	15.22	14.22	
14.82	15.14	14.9	15.3	14.92	14.88	15.22	15.05	14.76	15.31	13.97	14.85
14.73	15.05	14.9	15.25	14.88	15.18	15.14	14.98	14.55	15.31	13.92	14.8
15.33	14.95	15.2	15.65	14.97	15.11	15.22	14.91	15.25	15.22	14.63	15.5
15.32	14.72	15.15	15.45	15.15	15.34	15.36	14.83	15.39	15.51	14.67	15.5
15.36	14.40	14.7	15.65	15.06	15.09	15.12	14.39	15.26	14.98	14.57	15.35
15.39	14.36	14.5	15.55	15.25	15.31	15.23	14.47	15.31	14.88	14.62	15.4
15.25	14.97	14.55	15.4	15.19	14.03	14.97	14.63	15.55	14.31	14.41	14.65
15.59	14.76	14.5	15.55	15.4	14.33	15.19	14.72	15.35	14.45	14.52	14.55
15.37	14.9	14.85	15.5	15.25	13.90	15.28	14.93	15.22	14.59	14.47	14.7
15.50	14.89	14.8	15.55	15.27	13.98	15.42	14.81	15.58	14.50	14.66	14.6
15.58	15.3	14.95	15.35	15.14	13.93	14.92	15.2	15.4	14.83	14.39	15.2
		14.85	15.25								
15.45	15.33	14.85	14.4	14.99	14.40	14.96	15.36	15.41	14.99	14.01	15.3
15.45	15.32		14.35	14.95	14.37	14.81	15.25	15.32	14.98	14.02	

Julian Day	No. 28	No. 29	No. 30	No. 31	No. 32	No. 33	No. 34	No. 35	No. 36
28308.736						15.3?	15.25		
8309.651						15.4			14.9
.661	15.33	15.6	15.6	15.1	15.6	15.5	15.20	15.13	14.85
.670	15.25	15.5	15.43	14.99	15.49	15.3	15.05	15.10	14.95
.677	15.35		15.42	15.09	15.43		14.85?	15.10	14.9
.796	15.27	15.4	14.89	15.09	15.36	15.0	14.80	14.70	14.95
8365.608	15.1	15.53	15.34	14.96	15.57	14.9	15.20	14.75	15.05
8366.608	14.62	15.65	14.83	15.18	14.34	15.0	15.1	14.98	15.25
8399.596	15.56	15.52	15.44	15.00	14.7	14.4	14.8	15.17	14.9
8688.640							14.9:		
8689.642									
8692.632	15.29	15.3	15.35	14.87	14.97	15.1	14.65	15.10	14.7
8693.730	15.30	15.42	15.37	15.29	15.48	15.3	14.95	14.77	14.7
8696.631	15.47	15.6	15.35	15.15	15.40	15.2	14.55	15.18	15.15
8715.638									
9071.660	15.02	15.47	15.33	14.92	14.8	15.05		15.08	14.7
9072.698	15.02	15.42	15.35	15.32	15.38	15.1	14.9	14.99	14.9
9073.605	15.50	15.75	15.21	15.19	15.25	14.9	15.5	14.89	14.75?
9076.603							15.4		
9077.600						14.4			
9078.600						14.4	15.1		14.55:
9079.602	15.27	14.64	14.69	15.10	15.32		14.7	14.95:	15.30
9786.609	15.39	15.19	15.06	15.42	15.46	15.75	15.35	15.12	14.9
9787.608	15.39	15.55	15.53	15.17	14.61	15.55	15.1	15.20	15.25
9813.610	15.26	14.96	15.46	15.19	15.57	15.25		14.66	15.1
9814.612	14.87	15.20	15.25	15.49	14.65	15.5	15.35	14.94	15.25
9815.613	15.11	15.34	15.13		15.23	15.4	15.1	15.23	14.65
9816.611	15.42	15.52	15.38	15.19	15.44	15.15	15.2	15.15	14.95
30171.617	15.36	14.78	14.97	15.24	15.30	15.4	14.95	15.22	14.7
0172.615	15.23	15.26	15.53	15.43	14.75	15.6		15.13	14.9
0519.606	14.88	15.33	15.31		14.30	15.55	15.5	15.13	15.3
0520.606			15.33	15.26	15.15	15.6	15.35	14.85	15.25
0550.608	14.95	15.28	14.90	14.91	15.35	15.5		14.64	14.85
0553.604	15.25	14.87	14.98	14.90	15.12	15.25	15.5	14.71	15.35
0554.614	15.36	15.66	15.56	15.56	15.45	15.2	15.5	14.50	14.7?
0555.629	15.59	15.70	15.52	14.96	15.57	15.35		14.96	
0556.620	15.00	15.43	15.24	15.03	14.92	15.25	15.45	15.03	15.55
0586.572	15.19	15.04	15.39	14.81	15.26	14.55	15.25	14.75	15.3
0880.592						15.05	14.65		15.2:
.623	15.37	15.70	15.37	14.85	15.50	15.3	14.8	14.66	15.05
.659	14.61	15.49	15.33	15.1	15.41	15.05	14.8	14.60	15.15?
.690	14.51	15.70	15.50	15.3	15.58	15.4	14.9	14.70	15.05
.730	14.79	15.50	15.50	15.39	15.31	15.3	15.1	14.81	15.0
.760	14.97	15.37	15.46	15.44	14.22	15.5	14.95	15.05	15.0:
0880.788									
0883.593						15.05			
.630	15.28	15.22	15.42	14.95	15.10	15.05	15.2	15.11	15.1
.664	15.50	15.45	15.42	15.14	15.39	15.40	15.2	15.00	14.9
0884.622						15.30			
.680	15.32	15.61	15.25	15.42	15.60	15.55	14.95	14.70	15.0

No. 38	No. 39	No. 40	No. 41	No. 42	No. 43	No. 44	No. 45	No. 47	No. 52	No. 55
14.75							15.1			
14.85				12.4			14.6			
14.85	15.00	15.17	15.13	12.4	15.08	14.92	14.65	14.96	14.46	15.34
14.85	15.02	15.21	15.22	12.4	15.15	14.91	14.7	14.99	14.37	15.23
14.9	15.15	15.27	15.26	12.3	15.20	14.71	14.7	14.70	14.29	15.20
15.05	15.26	15.11	15.60	12.4	15.08	14.82	14.95	14.28	14.69	15.02
14.6	14.90	15.37	15.54	10.7	15.10	15.09	15.2	15.15	15.12	15.36
14.9	15.61	15.07	15.60	10.7	15.39	15.15	15.25	15.0	15.12	15.35
15.05	15.65	15.21	15.35	11.8	15.31	15.25	14.4	15.40	15.02	15.15
				11.9						
				12.1						
14.9	15.17	15.09	14.87	12.6	15.25	15.15	14.7	15.11	15.04	15.00
15.15	15.02	15.35	15.45	12.4	15.21	14.88	14.55	15.20	15.05	15.05
15.25	14.8	15.13	15.35	12.1	15.35	14.97	15.2	15.33	15.08	14.95
				12.4						
14.4	15.42	15.33	15.49	11.9	15.33	15.10	15.15	15.17	14.85	15.01
14.9	15.42	15.07	14.51	12.1	15.17	15.00	15.25	15.40	15.15	15.30
14.6	14.88	15.20	15.44	12.2	15.43	15.07	14.65	14.94	14.81	14.92
					15.20	15.02				
							14.7			
15.05	14.95	15.27	14.9	12.6			15.5	15.14	14.83	15.06
15.15	15.39	15.31	15.25	11.6	15.20	15.11	15.15	14.91	14.97	14.95
15.4	15.18	15.37	15.35	11.7	15.54	15.10	15.3	14.64	15.04	14.94
15.4	15.34	15.28	15.53	11.9	14.98	15.11	14.9	15.00	15.18	15.02
15.15	14.82	15.04	15.63	11.7	15.49	15.17	15.25	14.76	15.28	15.09
15.15	15.43	15.01	15.60	11.8	15.15	15.13	14.95	14.41	15.40	15.10
15.15	15.32	15.02	15.48	11.7	15.46	15.12	14.75	15.37	15.28	15.06
14.6	15.04	14.95	15.28	11.5	15.42	14.93	15.1	15.50	15.15	15.31
14.9	15.35	14.93	15.35	11.7	15.40	14.85	14.9	15.20	15.16	15.30
15.35	14.25	15.28	15.55	12.6						
14.15	15.52	15.24	15.57	12.7	15.53	15.24	14.75	15.21	14.37	15.10
14.8	15.38	15.06	14.37	11.7	15.24	15.57	14.95	14.99	14.41	15.25
14.5	15.37	15.34	15.03		15.38	15.06	14.65	15.20	14.33	14.88
14.9	15.47	14.78	15.02	11.7	15.18	14.90	14.7	14.90	14.35	14.78
15.4	14.76	14.88	15.27		15.60	14.40	15.25	14.80?	13.50	14.95
15.4	15.65	14.95	15.28	11.3	14.79	14.54	15.2	14.15	13.75	14.98
14.85	15.42	15.30	15.54	11.9	15.49	14.62	14.65	14.64	14.20	14.99
14.6					15.46	14.97	15.25	15.34	15.16	15.05
15.0	15.55	14.97	15.59	12.6			15.0			
15.1	14.85	15.10	15.47	12.4	15.29	14.76	14.95	14.90	14.78	15.05
15.05	14.31	15.25	15.54	12.4	15.17	14.61	14.95	14.69	13.95	15.16
15.15	14.50	15.31	15.50	12.4	15.32	14.70	15.15	14.95	13.98	15.36
15.3	14.77	15.32	15.58	12.4	15.25	15.39	14.9	14.93	14.26	15.34
				12.4	15.40	15.05	14.95	15.21	14.55	15.30
				12.4			14.8			
15.35	14.21	15.25	15.55	12.6	15.49	14.66	14.95	15.17	14.90	15.24
15.15	14.39	15.15	15.62	12.5	15.50	14.80	14.95	15.37	14.50	15.35
				12.2			14.9			
15.15	15.60	14.85	15.58	12.2	15.38	14.85	14.15	15.23	14.17	15.35

Julian Day	No. 28	No. 29	No. 30	No. 31	No. 32	No. 33	No. 34	No. 35	No. 36
30884.721	15.53	15.65	15.43	15.38	15.61	15.40	14.8	14.94	14.9
.771	15.44	15.52	15.38	14.90	15.41	15.30	15.1	15.06	14.9
0899.602	15.45	15.45	15.39	15.19	14.78	15.20		15.12	14.85
.647	15.50	15.67	15.48	15.31	15.14	15.15	15.35	15.14	14.7
.701	14.65	15.42	15.58	15.5	15.46	15.40	15.35	14.84	14.8
0900.604	15.37		14.91	15.41	15.20	15.20	15.2	14.90	15.2:
.638	15.4	15.21	15.31	15.41	15.41		14.95	14.77	
0901.632					15.60				
.676	15.32	15.43	15.08	15.15	15.60	15.30	14.7	14.87	14.9
0932.604	15.17	15.64	15.12	14.75	15.04	14.85	15.3	14.78	15.05
0933.589		14.90				14.85	15.4	14.80	15.25
1257.634	14.40	15.60	14.75	15.31	15.06	15.2	15.25	14.55	14.95
1259.604	15.25	15.14	15.25	14.77	15.5	14.7	14.8	15.15	15.3
1969.736	14.98	15.28	15.49	15.34		15.15	14.4	14.90	15.3
1970.698									
1976.641	15.47	15.48	15.11	15.34	15.55	14.45	14.8	14.65	15.35
1977.690	15.67	15.19	14.55	14.85	14.82	14.55	14.6	14.90	15.3
2000.641	14.56	15.56	15.46	15.16	15.23	15.25	15.5	14.99	14.85
2004.652	15.83	15.70	15.48	15.43	14.36	15.25	15.4	14.70	15.3
2006.599	14.66	14.99	15.41	14.87	15.17			14.01	15.3
2326.715	15.38	14.79	15.48	14.85	15.60	14.9	15.25	14.95	15.2
2328.739	14.98	15.54	15.6	15.06	14.18	15.15	14.85	14.90	15.35
2354.604	15.8	15.52	15.57	15.17	15.60	15.4	15.6	14.90	14.65
2355.607	15.46	14.67	15.34	15.17	15.70	15.4	15.15	15.22	15.6
2356.605	15.16	15.52	15.28	15.18	15.27	15.3	14.55	14.92	14.95
2357.604	15.2	15.26	15.37	14.88	14.37	15.45	15.3	14.69	15.3
2361.704	15.4	15.61	15.46	15.37	14.19	15.25	14.6	14.90	15.15
2733.605						15.5	15.6		15.6
2734.604	15.16	15.80	14.96	14.82	15.53	15.4	15.6	14.53	15.15
2740.608	15.13	14.89	15.03	14.84	15.45	15.35	15.4	14.83	15.2
2741.607	15.16	15.20	14.86	15.44	15.84	15.4	15.5	14.75	15.35
2742.648	14.75	15.73	15.60	14.86	14.68	15.4	15.5	14.66	15.2
2770.576	15.39	15.43	14.96	15.21	14.80	14.95	15.4	14.63	15.3
3068.668	15.35	15.55	15.30	15.27	15.26	15.4	15.1	14.73	15.5
3069.654	15.12	15.22	14.64	15.25	15.53	15.4		14.87	14.85
3095.604	14.68	16.02	15.74		15.10	15.3	15.45	15.35	15.4
3096.609	15.45	15.51	15.32	15.31	15.25	15.2	15.35	14.70	14.7
3476.602		15.36	15.13	15.44	15.36		15.45	14.54	
3477.601	15.34	15.68	15.48	15.01	15.80		15.35	14.69	14.95
3481.597		15.57	15.28	14.98	15.12	14.85	15.2	14.43	
3505.572	15.43	15.6	14.96	14.81	15.36	14.85	15.25	14.85	15.25
3823.649	15.09	15.16	15.09	14.98	15.57	15.15	15.25	14.16	
3858.636	15.40	15.76	15.36	15.46	15.03	14.45	15.35	15.12	14.95
3860.589	15.15	14.75	15.45	14.89	14.96	15.55	15.35	14.72	
4180.634	15.55	14.68	14.98	14.95	15.29	14.6	15.35	15.05	14.85
4181.607	15.59	14.95	15.67	15.01	15.64	14.45	15.25	15.31	15.25
4182.607	15.27	15.41	15.27	15.30	15.55	14.35	15.1	15.00	14.95
4538.633	14.49	14.76	15.47	15.02	15.29	14.5	15.55	14.59	
4539.634	15.49	15.28	15.29	15.04	15.67	14.45	15.45	14.57	15.3

No. 38	No. 39	No. 40	No. 41	No. 42	No. 43	No. 44	No. 45	No. 47	No. 52	No. 55
14.2	15.57	15.07	15.60	12.2	15.43	15.18	14.65	15.45	14.34	15.34
14.2	15.19	15.11	14.76		15.41	15.20	14.7	15.05	14.63	15.02
15.25	14.70	14.99	15.38	12.2	14.97	15.05	14.8	15.00	15.17	14.85
15.15	14.85	14.95	15.41	12.1	14.92	15.15	14.95	15.19	15.19	14.98
15.25	15.11	15.22	15.66	12.1	15.04	14.87	15.25	15.29	15.25	15.24
15.45	15.31	15.05	15.52	12.2	15.33	14.99	15.3?	15.14	15.19	14.84
	15.55:	15.25	15.44		15.46	15.21	14.95	15.14	15.25	15.06
14.2	15.52	15.27	15.52		15.15	15.19	15.35	15.07	15.45	15.36
15.25	14.78	14.77	15.80	12.9:	14.81	14.94	15.25	15.10	14.94	15.34
15.25				12.8:		14.95	15.2	14.82	15.07	
15.4	15.00	15.13	14.78	11.7	15.25	14.92	15.25	15.10	15.02	15.28
15.3	15.29	15.29	14.91	12.0	15.42	15.10	14.65	15.10	15.02	15.20
15.05	15.59	15.08	15.56	11.3	15.47	14.44	15.1	14.12	14.47	15.23
				11.4						
14.2	15.48	14.86	15.51	11.9	15.28	14.79	15.3	14.77	13.84	15.24
14.65	15.33	15.30	15.44	12.0	15.24	14.92	15.3	15.35	14.34	14.93
14.25	15.75	15.27	15.51	11.6	15.42	14.84	15.25	15.20	14.73	15.30
15.25	14.66	15.27	14.65	12.0	15.61	14.75	14.9	15.33	14.34	14.99
	15.18	15.27	14.82	12.3	15.33	14.72	15.25	15.29	15.21	15.18
14.6	15.69	14.97	15.15	11.1	15.46	14.67	15.25	14.92	13.93	14.81
15.4	15.21	15.32	15.54	10.5?	15.37	14.82	15.45	14.63	14.25	15.05
15.3	15.02	14.98	15.36	11.0	15.60	14.77	15.5	14.77	15.32	15.12
15.4	15.05	15.07	15.48	11.0	15.15	14.68	15.05	14.25	15.12	15.03
15.15	15.46	15.17	15.55	11.5	15.69	14.80	14.55	15.00	14.92	14.78
15.2	15.18	16.2	15.68	11.7	15.11	14.68	15.25	15.17	14.92	14.95
15.3	15.33	15.25	15.40	11.7	15.35	15.05	14.95	15.20	15.01	15.32
14.4							14.95			
14.9	15.18	15.43	15.03	12.3	15.31	14.92	14.6	14.80	14.25	14.96
14.3	15.16	15.39	15.73		15.48	14.57	15.3	14.89	14.13	15.08
14.3	15.21	15.33	15.63	11.5	14.86	14.66	14.95	14.89	14.10	15.4
14.85	14.15	14.80	15.77	11.7	15.56	14.53	14.55	14.37	14.06	15.21
15.25	15.35	14.92	15.63	11.7	15.57	14.65	14.9	14.8	14.34	15.32
15.05	15.40	15.22	15.39	12.5:	15.27	14.83	15.0	14.51	14.31	14.98
15.2	14.70	15.30	15.02	12.6	15.60	14.63	15.2	14.01	13.95	14.87
	15.21	14.83	14.23	12.5	15.10	14.65		14.53	14.09	15.13
15.2	15.07	15.31	14.82	12.4	15.52	14.70	14.55	14.34	14.35	14.91
	14.31	14.82	15.53			14.50		13.98		15.06
15.25	15.59	14.82	15.42	11.6	15.56	14.61	14.65	15.23	15.09	15.14
	15.21	15.12	14.75	12.0	15.50	14.80	15.1	14.63	14.59	15.10
14.35	15.08	15.13	14.91		14.96	14.90	14.85	15.33	14.79	15.11
14.9	14.78	15.27	15.06		15.31	14.25	14.7:	13.60	14.00	15.11
15.25	15.66	14.94	15.66	12.2	15.48	14.52	15.6	15.0	14.32	15.23
15.45	15.26	14.95	15.59	12.1	15.55	14.65		14.90	14.23	15.20
14.1	15.12	15.40	15.62	10.7	15.34	14.78	14.55	15.29	14.66	15.11
14.35	15.50	15.75	15.41	10.7	14.75	14.65	15.2	14.87	14.50	15.41
14.8	15.41	15.33	15.56	11.3	15.49	14.64	14.9	14.57	14.38	15.02
14.4	14.26	15.29	15.6	11.6	15.49	14.55	15.25	14.77	14.93	15.07
14.6	15.48	15.65	15.65	10.8	15.16	14.51	14.95	14.84	14.86	15.1

Julian Day	No. 28	No. 29	No. 30	No. 31	No. 32	No. 33	No. 34	No. 35	No. 36
34540.613	15.39	15.58	14.95	15.48	15.63	15.2	15.25	14.86	15.35
4572.602	15.25	15.38	14.75	14.77	15.50	15.3	15.25	14.68	15.05
4573.635	15.07	15.41	15.35	15.08	15.40	15.5	15.25	15.16	14.7
4574.602	15.12	15.84	15.74	16.01		15.5	14.65	15.52	15.25
4575.603	14.78	14.93	14.91	14.92	14.57	15.6	15.45	14.64	15.15
4929.623	15.28	15.39	15.52	15.35	15.41	15.6	15.45	14.95	
5273.612	15.11	15.22	15.55	14.87	15.53	15.5	14.75	14.81	14.95
5274.609	14.60	15.43	15.33	15.33	14.36	15.55	14.95	14.61	15.25
5275.610	15.48	15.93	15.15	15.41	14.97	15.5	15.5	14.65	14.95
5307.600	15.40	15.56	15.13	14.95	14.57	15.4	14.8	14.69	14.95
5308.599	15.21	15.70	15.53	15.35	15.09		15.6	14.95	
5309.600	15.37	15.18	15.60	15.26	15.49	15.4	15.25	15.27	15.15
5310.600	15.03	15.01	15.19	14.90	15.53	15.25	14.95	14.69	14.9
5658.601						15.15	15.35		15.15
5661.602			14.65	15.16	15.42	15.1	14.8	15.04	15.0
5685.588	15.34	15.48	15.55	15.43	15.54	14.85	15.2	15.12	15.2
5687.592	15.02	15.48	15.66	15.17	14.68	14.85	14.95	14.53	15.3
5688.590	14.62	15.55	15.46	15.49	15.27	14.9	15.3:	14.76	
6752.607	15.26	15.74	15.49	15.47	15.65	15.7	15.4	15.07	15.15
6753.602	14.80	15.87	15.01	15.34	15.30	15.6	14.95	15.27	15.2
7113.610	14.73	15.05	15.07	15.38	14.98	15.4	15.15	14.65	14.9
7115.636	15.36	15.70	15.28	14.95	15.47	15.6	15.25	15.04	15.15
7116.640	15.36	15.55	14.95	15.38	15.43	15.6	15.15	14.72	14.95?
8198.614	15.39	15.57	15.15	14.90	15.19	15.3	15.4	14.87	15.5
8199.629	15.12	15.56	15.15	15.39	15.45	15.4	15.4	14.92	
8584.628	15.24	15.45	14.84	15.25	15.50		14.9	14.94	15.5
8586.605	14.59	15.08	15.34	14.92	15.44	14.55	15.7	15.41	
9262.779	15.15:	14.60	15.20	15.28	15.41			14.65	
.785	15.29	14.62	15.21	15.4	15.48	15.4	15.25	14.69	14.9
9265.585						14.55	15.5		
.680	15.48	15.48	15.16	14.96	15.13	14.9:		14.83	
.684									
.772	15.35:	15.61:	15.14	15.28	15.32			14.97:	
.816	15.40	15.61	15.38	15.40	15.55	15.6	14.5	14.70	14.85
.819	15.37	15.63	15.37	15.35	15.51	15.3	14.5	14.64	14.85
.847	15.55	15.63	15.51	15.48	15.67	15.65	14.65	14.64	14.7
9270.772	15.27	15.67	15.54	14.87	15.22	15.4	15.5	14.62	15.3
.776	15.35	15.62	15.49	14.87	15.28	15.3	15.4	14.73	
.798	15.07	15.81	15.49	14.93	15.31	15.5		14.41	15.2
.803	15.31	15.79	15.58	14.94	15.29	15.25	15.5	14.61	14.9
9271.615	15.11	15.58	15.03	14.83	14.76	14.55	14.95	15.03	14.95
.619	15.45	15.74	15.06	14.80	14.90	14.4	14.95	15.17	15.0
.647	15.10	15.61	15.10	14.73	14.93	14.6	15.05	14.80	15.15
.651	15.31	15.69	15.09	14.83	15.10	14.65	14.95	14.81	15.15
.697	14.95	15.85	15.37	14.78	15.18	15.05	15.4	14.30	15.4
.701	15.40	15.71	15.17	14.86	15.31	14.9	15.05	14.57	15.0
.722	15.32	15.36	15.36	15.01	15.32	15.25	15.3	14.52	15.05
.725	15.43	15.42	15.27	14.93	15.43	14.95	15.3	14.62	15.15
.771	15.36	15.03	15.40	15.27	15.53	15.5	15.25	14.67	15.3
.776						15.25	15.15		
.817	15.38	14.73	15.45	15.38	15.58	15.4	15.25	15.00	15.3
.820	15.32	14.77	13.37	15.30	15.47			14.93	

No. 38	No. 39	No. 40	No. 41	No. 42	No. 43	No. 44	No. 45	No. 47	No. 52	No. 55
14.9	15.33	14.90	15.64		15.44	14.56	15.4	14.73	14.79	15.13
14.8	15.38	15.42	14.86	11.7	15.30	14.90	15.3	15.20	15.20	15.23
15.15	15.30	14.84	15.12	11.6	15.42	15.02		15.16	15.21	15.14
15.15	14.76	14.95	15.00	11.7	15.24	14.95	14.7	15.05	15.09	
15.25	15.84	15.01	15.15		15.51	14.84		14.75	15.05	15.30
14.6	15.77	14.89	15.63	11.3	14.88	14.90	15.25	15.25	14.42	14.78
15.15	15.57	15.03	14.45		14.96	14.83	14.95	15.35	14.62	14.95
15.4	15.35	14.96	14.31	12.2	15.40	14.62	14.65	14.83	14.48	14.91
15.05	14.98	14.64	14.25	12.5	14.67	14.35	15.15	15.10	13.92	14.95
15.25	15.37	14.95	15.55	12.5	15.49	14.77	15.1	15.17	14.31	15.15
	14.98	14.92	15.65	12.2	15.00	14.82		14.84	14.13	15.19
15.25	15.70	15.17	15.63	12.4	15.51	15.00	14.95	14.95	14.24	15.28
14.15	15.51	15.23	15.69	11.9	14.85	14.88	15.0	14.26	14.25	15.16
15.2				12.2		14.98	15.25			
14.6	15.15	15.50		12.9	15.32	14.81	15.4	14.90	15.26	15.31
14.6	14.96	14.83	14.97	12.1	14.82	14.67	15.25	14.98	14.84	15.39
15.1	15.62	15.13	15.16		14.74	14.60	15.25	14.95	14.58	15.37
	15.15	15.27	15.37		15.39	14.62		14.73	14.81	15.30
14.85	15.59	15.20	14.77	11.4	14.87	14.67	14.6	15.60	14.73	15.13
15.15	15.56	15.06	14.77		15.57	14.78	15.15	15.39	14.18	15.39
15.25	15.48	14.93	14.33	11.0	15.25	15.07	15.0	15.59	15.13	15.32
15.05	14.45	15.39	15.06	10.9	14.98	15.10	15.25	15.15	15.15	15.26
	15.53	15.05	15.18	11.2	15.51	15.10		15.05	15.04	15.25
14.6	15.41	15.19	15.65	10.8:	15.22	14.93	14.6	15.30	14.29	15.02
	15.03	15.25	15.62		15.38	14.94		15.55	14.14	15.10
15.3	15.56	15.05	15.45	11.5	15.10	15.23	14.7	14.78	15.16	15.10
15.25	15.1	14.95	14.92	11.6	15.21	15.23		15.51	15.35	14.94
	14.87	14.87	15.35	12.1	14.76	14.70		15.00	14.55	15.10:
15.15	14.82	14.92	14.96	12.4	14.93	14.65	15.25	15.16	14.65	15.1
14.8:										
15.4:	14.81	14.70	15.55	12.2	15.22	14.58		14.09	14.82	15.37
				12.4						
	14.93	15.15?	14.6:	12.2	15.48	14.77		14.62?	14.73	14.96:
15.25	15.22	15.25	14.79	12.8	15.42	14.71	15.5	14.56	14.28	14.94
15.25	15.27	15.33	14.90	12.5	15.46	14.89	15.1	14.83	14.37	14.79
15.3	15.41	15.41	14.95	12.8	15.61	15.00	15.2	14.92	14.09	14.90
14.9	15.54	14.85	15.20	12.6	15.17	14.83	15.4	14.89	14.74	14.89
14.9	15.50	14.92	15.35	12.6	15.21	14.92		15.10	14.95	14.90
14.9	15.58	14.83	15.31		15.24	14.84	15.3	14.79	14.40	14.91
14.9	15.60	14.88	15.41	12.5	15.22	14.96	14.9	14.90	14.73	14.87
14.2	14.77	15.17	14.51	12.6	15.42	14.76	14.5	14.45	14.96	15.20
14.15	14.63	15.15	14.27	12.6	15.48	14.80	14.7	14.48	15.08	15.40
14.5	14.95	14.93	14.73	12.5	15.49	14.66	14.85	14.15	14.87	15.10
14.45	14.91	15.0	14.65	12.6	15.55	14.70	14.75	14.37	15.14	15.09
14.9	15.36	14.75	14.85		15.48	14.67	14.95	14.21	14.71	14.92
14.75	15.05	14.81	14.90	12.8	15.60	14.63	14.75	14.49	15.12	14.83
14.9	15.22	14.93	15.10	12.8	15.37	14.46	14.85	14.41	14.97	14.90
14.95	15.15	14.85	15.10	12.8	15.55	14.78	14.95	14.74	15.28	14.81
15.15	15.35	15.05	15.42	12.6	15.55	14.90	15.15	14.78	14.91	14.91
15.05				12.5			14.85			
15.25	15.44	15.15	15.30	12.5	15.47	15.02	15.25	14.90	14.58	15.13
	15.42	15.22	15.50	12.4	15.53	14.97		15.12	14.55	15.02

Julian Day	No. 58	No. 59	No. 61	No. 62	No. 63	No. 64	No. 65	No. 66	No. 67
28308.736					15.25	15.05			
8309.651									
.661	14.65	14.93	15.51	15.60	15.35	15.1	15.15	15.40	
.670	14.76	15.02	15.42	15.36	15.45	14.85	15.15	15.36	
.677	14.86	15.01	15.38	15.36	15.5	14.85	15.10		
.796	15.41	15.32	15.51	14.97	15.45	15.05	14.86	15.17	
8365.608	15.46	15.27	14.62	15.51	14.95	15.6	14.41	15.05	
8366.608	15.16	15.13	15.47:	14.98	14.8	15.5	14.57	15.10	
8399.596	15.02	14.94	15.46	15.30	14.95	14.9	15.25	14.90	
8688.640					14.65	14.7			
8692.632	15.55	15.30	14.96	15.30	14.65	15.05	15.05	15.45	15.25
8693.730	15.44	15.37	14.91	15.35	14.95	15.05	15.2	15.48	
8696.631	15.60	14.90	15.03	15.32	14.65	15.6	15.22	15.20	15.05
9071.660	15.09	14.62	15.42	15.29	15.45	15.15	14.68	15.29	
9072.698	15.23	14.60	15.40	15.17	15.2	15.25	14.65	15.11	15.7
9073.605	15.18	15.42	15.00	15.36	15.25	15.0	14.53	15.5	15.15
9076.603					15.25				
9078.600					15.1	15.0			14.85
9079.602	15.30	15.20	15.34	15.20	15.35	14.85	14.92	15.35	14.9
9786.609	15.65	14.78	14.69	14.98	15.25	15.7	14.92	15.42	14.5
9787.608	15.60	14.64	15.60	15.51	15.25	15.35	14.95	15.50	14.6
9813.610	15.56	15.01	15.48	14.97	15.25	15.65	15.16	15.36	
9814.612	15.53	15.33	15.23	15.43	15.35	15.75	15.31	15.62	15.15
9815.613	15.51	15.37	14.68	14.90	15.25	15.7	15.30	15.47	
9816.611	15.32	15.40	15.42	15.41	15.35	15.5	15.18	15.25	
30171.617	15.15	15.30	15.0	15.00	15.25	15.5	15.01	15.5	14.95
0172.615	15.14	15.11	15.55	15.44	15.25	15.4	15.08	15.4	15.05
0519.606	15.64	15.24	15.02	15.18	14.5	15.55	15.04	15.44	14.75
0520.606	15.50	15.24	15.71	15.04	14.5	15.7	15.11	15.52	15.15
0550.608	15.28	15.20	15.37	15.08	15.25	14.55	14.95	14.94	15.05
0553.604	15.51	14.81	15.44	15.13	15.35	14.65	14.00	15.75	
0554.614		14.47	15.77	14.83	15.45	15.75	13.96	15.57	
0555.629	15.21	15.20	15.40	15.55	15.35	15.7	14.75	15.23	
0556.620		15.33	15.06	15.03	15.35	15.65	14.68	15.01	
0586.572	15.58	14.38	15.56	15.31	15.35	15.65	15.07	15.33	15.05
0880.592					15.25	15.55			14.9
.623	15.70	15.38	14.59	15.40	15.25	15.55	14.98	14.90	14.9
.659	15.45	15.30	14.70	15.38	15.35	15.55	14.96	15.02	14.95
.690	15.70	15.35	14.88	15.45	15.45	15.55	15.2	15.10	15.2
.730	15.57	15.34	14.89	15.07	15.35	15.55	15.10	15.28	15.15
.760	15.65?	15.37	15.08	14.99	15.35	15.7	15.22	15.44	15.6
.788									
30883.630	15.59	14.42	15.21	15.01	15.25	15.0	15.15	15.45	15.45
.664	15.69	14.75	15.35	15.23	15.35	15.1	15.31	15.53	15.6
0884.622						14.7			15.15
.651						14.6			15.4
.680	15.66	14.45	14.95	14.92	15.35	14.75	15.26	15.46	15.75
.721	15.65	14.64	15.23	15.05	15.45	15.05	15.27	15.50	15.35
.771	15.5	14.90	15.30	15.10	15.35	15.15	14.03	15.11	15.1

No. 68	No. 69	No. 70	No. 71	No. 72	No. 73	No. 74	No. 75	No. 76	No. 77	No. 78
	15.15									
	14.95									
	15.0	14.63	15.7		15.30	14.26	15.17	15.10	14.84	15.20
	15.05	14.78	15.51	15.48	15.31	14.30	15.07	14.99	14.84	15.22
		14.79			15.33	14.34	14.95	15.20	14.96	15.20
	15.55	15.45	15.45	14.51	15.17	14.35	15.05	14.66	14.82	14.95
	15.15	15.24	14.85	15.53	14.98	14.42	15.40	14.97	14.94	15.00
	15.35	15.12	14.53	15.01	15.01	14.35	15.10	15.24	15.01	15.26
		14.64			14.87	14.40	15.30	15.12	15.23	15.20
	14.7									
15.25	14.9	15.62	15.61	15.5	15.47	14.14	15.35	15.16	14.80	15.14
14.9	15.15	15.59	14.84	15.5	15.42	14.33	15.28	14.83	15.18	15.0
15.45	15.15	15.8	15.80	15.85	15.08	14.45	15.45	15.00	15.29	15.02
15.65	15.25	15.47	15.38	15.16	15.17	14.36	15.32	14.84	15.20	15.01
15.3	15.0	15.18	15.48	15.67	15.02	14.06	15.25	15.22	15.30	15.06
15.4	15.8		15.15	15.52	15.63	13.96	15.35	15.21	15.16	15.29
	14.7									
15.25	14.65	15.47	14.77	15.15	15.28	14.42	15.25	15.01	14.66	15.06
15.4	15.9	15.60	15.13	15.59	14.90	14.45	15.42	15.11	15.20	15.04
15.7	15.7	14.92	14.85	15.51	14.85	14.28	15.35	15.17	15.39	15.40
15.05	15.75	15.68	15.75	15.63	15.39	13.84	15.37	14.98	15.15	15.06
15.3	15.6	15.74	15.87	15.56	15.37	14.38	15.65	14.95	15.37	15.33
		15.15		14.63	15.03	14.35	15.10	15.23	14.92	15.28
		14.85	15.34	15.07	15.11	14.41	15.25	14.95	14.82	15.11
15.2	15.75	15.8	15.44	15.22	14.85	14.46	15.42	15.03	14.91	15.22
15.05	15.75	15.65	15.49	15.11	14.95	14.37	14.95	14.81	15.10	15.30
14.65	15.3	15.39	15.25	14.49	14.87	13.94	15.02	14.97	14.9	15.15
15.15	15.4	15.63	15.61	15.55	14.90	14.30	15.46	15.02	14.78	15.28
15.05	15.35	14.78	15.38	15.00	14.90	14.50	15.31	14.76	15.11	15.04
15.15	15.5		15.70	15.35	14.65	14.0	15.24	14.57	14.74	15.11
		15.29			14.77	14.03	15.33	15.27	15.15	14.77
		14.90			14.80	14.30	15.69	14.93	15.22	14.95
		15.60			14.78	14.78	15.24	14.74	15.33	15.26
15.05	15.25	15.47	14.84	15.08	14.75	14.22	14.96	14.97	14.75	15.26
	15.3?									
15.55	15.55	14.90	15.44	15.23	15.49	14.30	14.87	15.05	14.63	14.92
15.5	15.55	14.86	15.51	15.35	15.26	14.27	15.06	15.22	14.83	14.94
15.5	15.55	15.0	15.58	15.49	14.98	14.27	15.19	15.35	14.99	15.11
15.25	15.6	15.2	15.60	15.42	14.95	14.34	15.23	15.29	14.95	15.21
15.2	15.65	15.45	15.60	15.58	15.03	14.37	15.29	15.28	15.03	15.33
15.35	15.65	15.46	15.34	15.42	15.44	13.55	15.30	15.00	15.28	15.24
15.5	15.70	15.69	15.58	15.52	15.59	13.80	15.39	15.18	15.40	15.4
	15.5?									
	15.35									
15.6	15.7	14.50	15.65	15.55	15.49	14.20	15.30	15.12	15.02	15.26
15.4	15.4	15.61		15.66	15.45	14.38	15.22	15.08	15.00	15.40
15.05	15.5	15.36	15.43	15.39	15.05	14.28	15.06	14.92	14.77	15.17

Julian Day	No. 58	No. 59	No. 61	No. 62	No. 63	No. 64	No. 65	No. 66	No. 67
30899.602	14.78	15.37	15.33	14.92	15.35	15.65	15.05	15.22	15.25
.647	15.42	15.34	15.52	14.90	15.45	15.5	14.04	15.07	
.701	15.56	15.38	15.60	15.24	15.5	15.55	14.3	15.40	
0900.604	14.95	15.16	14.75	15.31	15.25	15.35	14.1	14.87	14.95
.638	15.46	15.35	15.12	15.42	15.5	15.55	14.35	15.18	
0901.676	15.69	15.21	14.77	15.36	15.55	15.3	14.93	14.99	
0932.604		15.15	15.42	15.12	15.55	14.9	14.75	15.10	
0933.589		14.85	14.90		15.5	15.5			
1257.634	15.36	14.39	14.46	14.95	14.4	14.35	15.07	15.55	14.7
1258.625					14.5	15.4			14.9
1259.604	15.56	15.25	15.53	14.99	14.6	15.5	15.25	15.33	15.3
1969.736	15.56	15.16	15.33	15.45	15.65	15.8	14.64	15.30	15.25
1976.641	15.56	15.32	15.45	14.94	15.5	15.5	15.21	15.08	15.4
1977.690	15.71	15.33	15.31	14.91	15.5	15.5	15.15	15.12	15.45
2000.641	15.41	15.40	15.46	15.30	14.85	15.65	15.18	15.25	15.05
2004.652	15.95:	15.00	15.54	15.43	14.5	14.9	15.10	15.65	15.2
2006.599	15.29	15.63	14.73	15.23		15.3	14.78	14.85	14.7?
2326.715	14.60	15.20	14.86	15.05	14.5	15.5	15.18	14.82	
2328.739	14.78	14.63	15.38	15.25	14.95	15.05	14.00	15.11	
2354.604	15.60	15.53	15.10	15.12	14.95	15.6	14.38	15.38	14.95
2355.607	15.09	15.32	14.97	15.47	15.15	15.4	13.78	14.98	14.9
2356.605	15.59	15.37	15.57	15.07	15.0	15.3	14.36	15.03	14.9
2357.604	14.78	15.21	15.35	14.91	15.25	14.95	14.36	14.93	14.9
2361.704	15.35	14.48	15.49	15.34	15.4	15.6	15.20	15.08	15.25
2733.605					15.5	15.4			
2734.604	15.90	14.85	15.48	15.35	15.3	15.5	15.05	15.27	15.15
2740.608	15.79	14.31	14.48	14.75	15.4	15.35	14.42	15.48	15.0
2741.607	15.75	15.70	15.74	15.51	15.4	15.6	14.85	15.06	15.0
2742.648	16.0	15.32	15.60	14.87	15.4	15.4	14.23	14.93	14.85
2770.576	15.64	15.12	15.45	15.28	14.25	15.3	14.69	15.34	15.05
3068.668	15.55	14.98	14.97	15.46	14.5	14.65	14.95	15.2	15.25
3069.654	15.65	14.40	15.49	14.97	14.65	15.6	14.71	15.4	
3095.604	14.85	14.45	15.27	15.58	14.5	15.6	15.18	15.33	14.9
3096.609	15.12	15.36	14.74	14.81	14.5	15.25	15.08	15.69	15.2
3476.602	15.56			15.21	15.2	15.05	14.09	14.81	14.9
3477.601	15.51	15.30	14.80	15.35	15.5	14.75	14.43	14.92	15.05
3481.597	14.95	14.62	14.93	14.81	15.5	15.5	15.10	15.20	14.95
3505.572	15.88	15.25	15.39	14.93	15.5	15.4	15.08	15.36	15.15
3823.649	15.36	14.46	15.39	15.39	15.0	15.4	14.10	15.65	15.3
3858.636	15.53	15.32	15.05	15.32	15.25	15.55	15.13	15.08	15.5
3860.589	15.56	15.21	15.44	15.27	14.9	15.4	14.96	15.31	14.95
4180.634	15.28	15.45	15.48	14.87	14.95	14.95	15.35	15.39	15.05
4181.607	15.24	15.34	14.84	15.55	14.8	14.75	15.11	14.00?	14.95
4182.607	15.20	15.14	14.78	14.91	14.95	15.6	14.98	14.84	15.6
4538.633	15.75	14.95	14.69	15.07	15.45	15.6	14.92	15.00	15.4
4539.634	15.80	14.53	15.62	15.35	15.5	15.55	14.88	14.96	15.55
4540.613	15.82	15.05	15.5	15.19	15.5	15.25	14.85	15.15	14.95
4572.602	15.77	15.10	15.67	14.90	15.5	14.75	14.61	14.83	15.05
4573.635	15.70	15.32	15.46	15.26	15.45	14.65	15.01	14.88	15.1

No. 68	No. 69	No. 70	No. 71	No. 72	No. 73	No. 74	No. 75	No. 76	No. 77	No. 78
15.0	15.8	15.45	15.17	15.21	15.65	14.16	15.32	14.82	15.20	15.34
15.25	15.7	14.82	15.20	15.05	15.47	14.18	15.57	15.10	15.30	14.88
15.6	15.7	15.18	15.63	15.4	15.31	14.15	15.67	15.29	15.29	14.96
15.15	15.6	15.92	15.39	15.77	15.60	14.40	15.05	15.27	15.31	15.41
					15.58	14.35	15.30	15.25	15.35	15.26
					15.44	14.42	15.63	14.86	14.72	15.18
		14.82			15.58	14.14	15.72	15.36	15.37	15.16
						13.85				
15.15		15.21	15.82	15.61	15.25	14.13	14.90	14.88	14.83	15.20
15.15	15.5	15.75	15.58	14.91	15.08	13.92	15.20	14.95	15.25	15.04
15.25	15.25	15.80	15.85	15.39	15.26	14.41	15.23	14.95	15.39	15.06
15.05	14.95	15.31	15.60	15.51	14.92	14.23	14.89	14.74	14.71	14.96
15.15	15.5	14.90	15.85	15.60	14.91	14.33	15.58	15.10	14.81	15.12
14.9	15.65	15.41	15.42	15.25	15.39	14.32	15.05	15.20	15.18	15.26
14.85	15.7	15.98:	15.66	15.49	15.63	14.05	15.18	15.03	14.70	15.37
14.85?		15.51	15.18	15.60	14.95	14.44	15.18	14.58	14.80	14.80
15.1	15.6	14.48	15.32	14.60	15.12	14.12	15.50	15.32	14.89	15.00
15.35	15.6	15.70	15.45	15.70	15.22	13.92	15.57	14.79	15.18	15.18
15.05	15.6	14.99	15.51	15.48	14.90	13.83	15.82	14.85	14.91	14.87
14.9	15.5	15.40	15.02	14.91	14.85	13.97	15.36	15.18	15.25	14.83
14.9	15.4	15.33	14.98	14.56	14.83	14.35	15.16	14.94	15.28	15.19
15.05	15.35	15.04	15.14	14.43	14.90	14.36	15.10	14.80	15.35	15.36
14.85	15.25	15.59	15.31	15.30	15.05	14.29	15.56	15.18	15.38	14.88
15.2	15.55									
14.9	15.3?	14.86	14.42	15.21	15.33	13.90	15.33	14.94	15.26	14.90
14.95	15.6	14.78	14.24	14.66	15.05	14.25			14.74	15.32
15.05	15.6	15.83	14.16	15.26	14.82	14.13	15.07	14.89	14.85	15.36
14.9	14.6	15.85	14.48	15.65	14.98	14.13	15.44	14.98	15.02	15.25
15.25	15.5	15.85	15.83	15.55	15.36	14.16	15.20	14.85	15.08	15.00
15.05	15.55	15.52	15.13	15.65	15.22	14.05	15.30	15.20	14.80	15.20
15.05	15.7	14.83	15.92	15.48	15.25	13.93	15.54	15.13	14.92	15.04
15.05	15.0	15.39	15.64	15.69	14.75	13.89			15.02	14.87
15.2	15.25	16.02	15.90	15.43	14.95	14.40	14.73	14.64	14.76	15.00
15.2	14.75	15.19	15.41	15.37	14.77	14.25	15.55	15.10	15.43	14.72
15.4	14.9	15.43	15.69	14.81	14.42	14.16	15.42	14.80	14.71	15.10
15.15	14.9	15.78	15.59	14.88	15.17	14.30	15.30	14.90	15.29	14.94
14.95	15.4?	15.53	15.67	15.73	15.29	14.28	15.29	14.93	14.73	15.31
14.85	15.5	15.0	15.8	15.32	15.35	14.20	15.59	15.05	15.17	15.12
15.3	14.9	15.61	14.5	15.41	15.3	13.52	15.62	15.18	15.45	15.26
15.0	14.55	15.10	14.79	14.68	14.94	14.24	15.30	14.79	14.84	15.01
14.95		15.02	15.52	15.20	14.98	14.19	15.44	14.76	15.39	15.37
15.25	15.4	14.30	15.42	15.04		14.20	14.95	15.15	14.66	15.01
15.3	15.65	15.12	15.68	15.59	14.58	14.43	15.36	15.11	14.71	15.00
15.25	14.9	14.91	15.53	14.81	14.90	14.27	15.31	14.85	15.15	15.36
15.05	15.05	15.35	15.58	15.69	15.25	13.79	15.37	14.86	15.25	15.40
15.25	14.85	16.10	15.62	15.75	15.25	14.01	15.65	15.29	15.39	14.85
15.25	15.6	14.60	14.00	15.33	15.15	14.20	15.45	15.20	15.38	15.26
15.15	15.5	15.56	14.73	15.32	15.20	14.30	15.06	14.89	15.19	15.18

Julian Day	No. 58	No. 59	No. 61	No. 62	No. 63	No. 64	No. 65	No. 66	No. 67
34574.602	15.85	15.55	15.60	14.85	15.4	15.7	15.03	14.92	15.45
4575.603	15.76	15.26	14.69	15.45	15.55	15.55	15.00	15.23	15.25
4929.623	16.0	15.39	15.70	15.49	14.9	15.45	14.59	15.09	15.4
5273.612	15.95	15.07	15.61	14.84	15.2	15.45	15.31	14.87	14.85
5274.609	15.68	14.53	15.28	15.40	15.1	15.45	14.94	15.13	14.9
5275.610	15.93	14.85	14.81	15.13	15.25	14.9	14.99	15.06	15.3
5307.600	15.08	14.85	15.45	15.28	15.45	14.7	14.99	15.07	14.95
5308.699	15.21	15.47	14.91	15.18	15.35	15.55	15.10	15.08	14.9
5309.600	15.13	15.55	15.60	14.96	15.3	15.45	15.27	15.45	14.9
5310.600	14.98	15.29	15.59	15.30	15.15	15.5	15.13	15.42	14.85
5658.601		15.45				15.45			14.9
5661.602	14.94	14.37	14.66	15.12	14.3	14.95	15.09	15.15	
5685.588	15.57	15.18	14.92	14.89	14.8	14.85	15.19	15.21	14.95
5687.592	15.77	14.30	15.70	14.91	14.7	15.7	14.89	15.25	15.3
5688.590	15.57	15.34	15.28	15.41	14.9	15.7	13.84	15.49	
6752.607	15.51	15.27	15.43	15.53	14.9	15.6	14.88	15.10	15.55
6753.602	15.82	15.43	15.37	15.15	14.7	15.55	15.03	14.70	
7113.610	15.43	15.16	15.62	15.46	15.4	15.6	15.12	15.40	15.4
7115.636	15.8	15.41	14.63	15.8:	15.15	15.6	15.12	15.50	15.6
7116.640	15.84	15.30	15.16	15.09	15.4	15.3	14.13	15.23	15.25
8198.614	15.27	15.33	15.49	14.90	15.5	15.4	15.00	15.66	15.3
8199.629	15.00	15.30	15.24	15.36	15.5	15.25	14.52	15.28	15.25
8584.628	15.51	15.43	15.73:	15.37	15.05	15.6	15.37	14.95	15.25
8586.605	15.76	15.31	15.40	15.35	15.05	14.85	14.56	15.25	14.85
9262.772					14.85				
.779	14.63	14.45	14.55	15.38	14.7	15.55	15.01	15.38	14.85
.785	14.89	14.36	14.61	15.37	14.7	15.5	15.06	15.30	14.9
9265.585					15.35	14.8			14.8
.620						14.85			14.85
.680	14.75	14.97	15.23	15.34		15.35	14.97	14.97	15.15
.772	15.2	15.26?	15.31	14.92		15.6	15.29:	15.29:	15.3?
.816	15.31	15.28	15.30	15.22	14.45	15.4	14.06	15.34	15.2
9265.819	15.46	15.38	15.51	15.07	14.55	15.55	14.20	15.37	
.847	15.35	15.41	15.57	15.37	14.55	15.6	14.13	15.57	14.85
9270.772	15.62	15.35	14.72	14.92	14.6	15.6	14.84	15.37	14.9
.776	15.62	15.33	14.83	14.86	14.65	15.55	15.02	15.40	14.8
.798	15.80	15.30	15.08	14.93	14.45	15.55	14.86	15.50	14.9
.803	15.80	15.41	14.92	14.77	14.4	15.6	14.95	15.55	14.9
9271.615	14.74	15.06	15.55	14.72	15.5	14.85	14.21	15.05	
.619	14.78	15.19	15.72	14.86	15.4	14.85	14.44	14.94	15.15
.647	14.94	15.09	15.38	14.77	15.5	15.05	14.25	14.97	15.4
.651	14.99	15.11	15.62	14.84	15.5	14.9	14.54	14.95	15.9
.697	15.38	15.46	15.69	14.95	15.55	15.1	14.66	14.84	15.4
.701	15.32	15.28	15.72	14.94	15.4	14.95	14.74	15.07	15.6
.722	15.33	15.21	15.47	15.05	15.6	15.25	14.61	15.12	15.3?
.725	15.50	15.35	15.68	15.02	15.4	15.15	14.91	15.15	
.761	15.70	15.33	15.67	15.33	14.55	15.4	14.95	15.45	14.9
.776					14.25	15.5			15.15
.817	15.56	15.28	15.27	15.45	14.45	15.6	15.07	15.32	
.820	15.53	15.32	15.18	15.35	14.6	15.5	14.97	15.58	14.85

No. 68	No. 69	No. 70	No. 71	No. 72	No. 73	No. 74	No. 75	No. 76	No. 77	No. 78
15.15	15.7	15.21	14.51	14.45	15.15	13.42	15.63	15.01	14.91	15.07
15.15	15.55	15.23	14.72	15.47	15.25	14.19	15.64	15.19	14.95	14.79
15.25	15.05	15.06	15.90	15.4	15.23	13.50	15.35	14.73	14.75	14.66
15.4	15.4	14.75	14.95	15.05	15.43	14.29	15.06	15.20	14.79	14.97
15.45	15.35	15.77	14.93	15.74	15.50	14.20	15.30	14.83	14.91	15.33
15.15	15.4	15.13	14.69	15.57	15.25	13.79	15.20	14.89	15.28	15.01
15.05	14.8	15.69	15.66	15.57	15.51	14.39	15.39	14.79	15.02	15.07
14.85	14.6	15.52	15.47	15.15	15.49	14.34	15.28	15.15	15.34	14.86
14.85	14.7	15.54	15.55	14.77	15.59	13.57	15.49	15.09	15.43	15.25
14.9	15.05	15.16	15.51	15.34	15.40	13.96	15.15	14.71	15.01	15.34
15.25?	15.25				15.25	14.28				
14.95	15.2	15.35	15.34	14.91	15.23	14.57	14.85	14.79	14.82	15.13
14.4	15.5	15.63	14.27	15.53	14.87	13.88	15.49	15.30	15.38	15.23
14.55	15.3	14.73	14.16	15.30	14.69	14.05	15.17	14.86	14.78	14.75
14.5	14.9	15.21	14.51	15.16	14.85	14.32	15.48	14.81	14.84	14.86
14.8	14.15	15.73		14.57	14.85	14.02	15.07	15.17	14.88	14.87
14.7	14.4	15.19	15.10	14.62	14.95	13.88	15.64	14.85	15.30	14.97
15.05	15.6	15.21	14.25	15.55	15.28	14.15	15.48	15.28	15.10	14.82
14.8	15.6	15.73	14.35	15.12	15.56	13.85	15.39	14.89	15.34	15.29
14.85	15.4	15.46	14.36	14.87	15.28	14.10	14.99	15.16	15.07	15.21
14.75	14.8	15.75	15.48	15.25	16.0	14.34	15.47	15.22	14.78	14.96
14.7	14.4	15.7	15.28	14.74	15.56	14.28	15.16	14.79	15.07	14.75
14.9	14.85	15.54	15.44	15.45	15.28	14.36	15.42	14.95	15.03	15.03
15.05	14.8	15.60	15.38	15.03	15.43	14.08	15.40	15.20	15.12	15.12
15.25		15.28	14.63	15.03	15.74	14.42	15.35	15.06	15.13	15.31
15.2	15.4	15.36	15.0	15.13	15.63	14.32	15.30	15.05	15.05	15.34
14.9	14.5									
14.85	14.5									
15.25	14.85	15.00	15.05	14.55	14.85	13.78	15.60	15.00	15.46	15.07
		15.31	14.97	15.12	15.27:	14.23	15.35:	14.76:	15.23	14.92:
15.15	15.7	15.43	15.07	15.26	15.34	14.08	15.57	15.14	14.90	14.81
15.2	15.7	15.65	15.16	15.20	15.46	14.15	15.47	14.93	14.77	14.90
15.25	15.6	15.46	15.26		15.51	14.03	15.56	15.25	14.90	15.06
15.35	15.7	15.27	14.5	14.73	14.89	14.00	15.23	15.11	15.51	14.95
15.4	15.65	15.35	14.67	14.83	15.06	13.93	15.10	15.04	15.36	15.10
15.4	15.7	15.4	14.79	14.91	15.05	14.03	15.19	14.96	15.55	14.71
15.3		15.35	14.89	14.89	14.73	14.15	15.01	14.85	15.46	14.79
14.95	14.95	15.58	15.25	15.09	15.41	13.84	14.85	15.01	15.39	
14.9	15.25	15.92	15.53	15.42	15.60	13.77	15.09	15.06	15.51	14.80
15.15	15.25	15.58	15.27	15.07	15.55	13.97	15.21	14.83	15.40	14.94
15.15	15.6	15.76	15.41	15.31	15.51	14.02	15.20	14.90	15.38	14.90
15.4	15.6?	15.50	15.37	15.53	15.36	13.72	15.28	14.87	15.32	14.83
15.1	15.6	15.91	15.61	15.78	15.48	14.07	15.15	14.80	15.05	15.15
15.25	15.6	15.05	14.70	15.58	15.11	14.07	15.27	14.90	14.90	15.23
15.2	15.65	15.20	14.60	15.67		14.11	15.16	14.68	14.79	15.27
15.35	15.65	14.73	14.56	15.42	14.95	14.25	15.34	14.77	14.79	15.34
15.3										
15.2	15.7	14.90	14.92	14.89	14.87	14.27	15.55	14.90	14.73	15.06
15.15	15.5	14.93	14.92	14.79	14.73	14.30	15.42	14.87	14.64	15.06

Julian Day	No. 79	No. 80	No. 81	No. 83	No. 84	No. 87	No. 92	No. 98
28309.651					12.2			
.661	15.05	14.97	15.55	15.5?	12.2	14.85	14.44	
.670	15.05	14.97	15.39		12.2	14.84	14.44	
.677	14.97	14.90	15.30		12.1	14.92	14.46	
.796	14.78	14.70	14.67	14.75	11.9	15.02	14.27	15.15?
8365.608	15.17	14.85	15.07	15.05	11.9	14.98	14.23	15.1
8366.608	15.10	14.84	14.58	15.7	11.0	15.03	14.37	15.5
8399.596	15.15	15.07	15.02		11.2	15.12	14.58	15.0
8688.640					10.7			
8692.632	14.86	15.18	14.57	14.4	11.2	15.16	13.93	15.4
8693.730	15.14	15.03	14.92	14.95	11.4	15.12	14.36	15.05
8696.631	14.85	15.29	14.97	15.0	11.6	15.12	14.38	15.6
8715.638					11.3			
9071.660	14.79	14.92	14.73	14.6	11.4	14.99	13.92	15.7
9072.698	14.92	14.96	15.02	15.6	12.1	15.25	14.40	15.05
9073.605	15.20	15.23	15.40	15.55	11.7	15.20	14.25	15.05
9077.600				15.25				
9079.602	15.04	15.15	15.07	15.3	10.8	15.04	14.07	
9786.609	14.84	15.00	14.93	15.0	12.0	15.13	14.18	
9787.608	14.75	15.00	15.42	15.25	11.8	15.21	13.78	15.3
9813.610	14.73	15.17	15.30	15.55	12.5	14.96	14.13	15.5
9814.612	14.82	15.25	15.10	15.45	12.5	15.18	14.39	15.55
9815.613	14.81	15.23	14.60	15.6	12.6	15.31	14.39	15.15
9816.611	14.88	15.32	15.44	15.3	12.5	14.95	14.43	14.6?
30171.617	15.12	15.08	15.42	14.9	11.6	15.25	14.49	
0172.615	15.14	15.11	15.43	15.6	11.8	15.0	14.03	15.05
0519.606	15.07	15.15	14.98	15.3	11.3	14.74	14.38	15.7
0520.606	15.10	15.05	14.63	15.6	11.4	15.10	14.43	14.95
0550.608	14.91	15.10	15.37	15.35	12.2	14.80	14.34	15.4
0553.604	14.85	15.26	15.01	15.35		14.80	13.92	15.55
0554.614	14.76	14.95	14.35	15.05	11.2:	14.76?	13.96	15.2
0555.629	14.84	15.24	15.40	14.85		15.0	14.18	
0556.620	14.93	15.05	15.40	15.55	11.3	14.93	14.30	15.9
0586.572	14.95	15.05	15.18	15.3	11.3	15.18	13.96	14.9
0880.592				15.25				15.4
.623	14.70	14.66	14.65	15.3	10.7:	14.8	14.32	15.0
.659	14.67	14.57	14.55	15.5	10.7:	14.79	14.40	
.690	14.84	14.88	14.77	15.4	10.0:	14.86	14.31	
.730	14.90	14.95	14.92	15.6	10.8	14.85	13.5	
.760	15.07	15.14	15.10	15.5	10.8	14.95	13.7	
.788					11.2			
0883.593				15.5?	11.4			15.4?
.630	14.65	14.66	15.26	15.3	11.2	14.78	14.09	
.664	14.80	14.87	15.41	15.5	11.3	14.92	14.27	14.9
0884.622					11.3			
.680	14.80	14.78	15.14	15.5	11.5	15.20	14.3	15.15
.721	15.10	15.06	15.38	15.3	11.5	15.31	14.57	
.771	15.15	15.18	15.40	15.5	11.6	15.20	14.47	15.3

Julian Day	No. 79	No. 80	No. 81	No. 83	No. 84	No. 87	No. 92	No. 98
30899.602	14.74	15.10	14.52	15.5	12.1	15.17	14.38	15.25
.647	14.72	15.15	14.74	15.3	12.1	15.15	14.35	15.1
.701	14.9	15.12	15.01	15.55	12.1	15.25	13.47	14.95
0900.604	14.77	15.07	15.47	15.5	11.7	15.04	14.2	
.638	14.88	15.18	15.42			14.98	13.5	
0901.676	14.95	15.35	15.54	15.4		15.25	14.29	15.25
0932.604	14.55	15.18	15.15	15.3		14.87	13.60	15.3
0933.589	14.52	14.87	14.45	14.95			13.79	
1257.634	15.00	14.80	15.34	15.3	11.1	15.10	14.12	15.25
1259.604	15.20	14.78	14.47	15.35	11.4	15.02	14.37	14.95
1969.736	14.63	14.59	14.81	15.3	11.3	14.63	13.57	15.5
1970.698					11.6			
1976.641	14.66	14.96	15.35	15.05	12.2	15.00	13.40	15.15
1977.690	14.62	14.75	15.45	14.9	12.0	15.27	13.89	15.3
2000.641	14.83	14.79	15.39	15.4	12.0	15.21	14.50	15.55
2004.652	14.68	14.65	15.61	15.5	12.6	14.95	14.28	15.6
2006.599	14.97	14.66	15.43	15.3	12.4	14.71	14.75	
2326.715	14.73	14.43	15.40	15.25	12.1	14.93	14.17	15.6
2328.739	14.60	14.54	15.71	15.6	10.7?	14.90	14.23	15.6
2354.604	15.08	14.83	15.55	14.9	11.2	14.95	14.40	
2355.607	15.06	14.71	15.53	15.2	10.9	15.29	14.37	15.3
2356.605	15.17	14.95	15.29	14.95	10.8:	14.83	13.81	15.4
2357.604	14.97	14.97	14.97	15.5	11.1	15.03	13.87	15.6
2361.704	14.87	14.65	15.42		11.3	15.21	13.99	
2734.604	14.80	14.75	15.28	14.9	11.4	15.21	14.12	
2740.608	14.59	14.82	15.13	15.1		14.73	14.11	
2741.607	14.85	14.93	15.19	15.6	12.4	15.06	14.34	15.25
2742.648	14.66		14.53	15.6	11.8	15.0	13.5	
2770.576	14.66	14.80	14.95	14.9	11.9	15.13	14.18	
3068.668	14.87	14.98	14.62	15.35		14.81	14.35	
3069.654	14.35	14.92	15.48	15.3	10.6:	14.95	14.08	
3095.604	14.86	15.13	15.56		10.7	15.06	14.47	
3096.609	14.76	15.17	15.00	15.2	11.2	14.81	14.16	15.55
3476.602			14.54			14.93	13.6	
3477.601	15.02	15.06	15.71	15.35	11.3:	14.80	13.9	14.95
3481.597	14.90	14.95	14.38		11.7	14.82	14.32	
3505.572	15.12	14.98	14.57	15.2	11.5	15.05	14.45	15.3 ?
3823.649	14.41	14.11	15.33			15.29	13.96	
3858.636	14.78	14.45	15.46	15.3	11.3	14.64	14.23	15.55
3860.589	14.75	14.97	14.61		12.0	15.20	14.41	
4180.634	15.02	15.16	15.32	15.4	11.2	14.92	14.35	15.25
4181.607	15.01	15.15	14.72	15.3?	10.8	15.24	14.30	15.15
4182.607	14.82	15.23	15.41	14.85	10.9	15.17	14.24	14.9
4538.633	14.89	14.88	15.35		10.9	14.83	14.00	
4539.634	14.84	14.90	15.37	15.3	10.9	14.95	13.80	15.55
4540.613	14.78	14.85	15.12			15.10	13.98	
4572.602	14.97	15.02	15.38	15.05	11.9	15.08	13.92	15.15
4573.635	15.11	15.17	15.41		12.3	15.30	14.47	
4574.602	15.14	15.05	15.53	15.4	12.8	15.45	14.43	15.6

Julian Day	No. 79	No. 80	No. 81	No. 83	No. 84	No. 87	No. 92	No. 98
34575.603	14.94	14.87	14.65	15.25		14.70	14.35	
4929.623	14.60	15.05	15.1		10.8?	14.80	14.16	
5273.612	15.22	15.20	15.5	15.4		15.09	13.75	15.05
5274.609	14.99	14.91	15.23	15.6	10.0:	15.15	13.95	
5275.610	14.99	15.10	14.77	15.3	10.7	14.55	13.95	15.55
5307.600	15.15	15.06	15.45	15.15	10.3:	15.02	14.28	
5308.599	15.15	14.91	15.23		11.3	15.12	14.36	
5309.600	15.24	15.08	14.87	15.15	11.6	14.92	14.44	15.7
5310.600	15.17	14.90	15.46	15.15	11.6	15.04	14.31	15.3
5658.601				15.2	12.0			
5661.602	14.74	15.01	15.36	14.75	12.7			
5685.588	14.95	14.89	15.55	15.25	12.2	14.91	13.70	
5687.592	14.42	14.93	15.32	14.7		14.61	14.10	
5688.590	14.84	14.85	14.82			14.89	14.23	
6752.607	14.58	14.5	15.35	15.5	11.9	15.02	14.26	15.6
6753.602	14.59	14.63	15.00	15.3	12.5	15.17	14.24	15.6
7113.610	14.73	14.88	14.95	15.2	12.2	14.89	14.32	15.6
7115.636	14.72	14.96	15.44	14.65	11.8	14.9	13.50	15.25
7116.640	14.82	14.88	15.38		11.3	14.99	13.89	
8198.614	14.89	14.97	14.50	15.45	10.5:	14.99	13.73	
8199.629	14.73	14.82	15.35			14.70	13.81	
8584.628	15.15	15.13	15.45	15.35	12.7	15.07	13.64	15.5
8586.605	15.16	15.27	15.21		12.4	15.10	14.27	
9262.779	14.66	14.91	15.50		11.6	14.95	14.47	
.785	14.78	14.82	15.45	15.3	10.8:	15.2	14.38	
9265.680	14.66	14.73	15.26		11.5	14.92	14.38	
.684					11.8			
.772	14.72:	15.16:	14.93:		11.6	15.06:	13.85	
.816	14.80	14.70	14.54	14.65	11.0:	15.07	13.80	15.5
.819	14.92	14.89	14.48	14.7	12.0	15.20	13.83	15.55
.847	14.98	14.81	14.68	14.9	11.4	15.00	13.74	15.6
9270.772	14.74	15.04	15.35	14.8	11.9	15.00	14.35	15.7
.776	14.87	14.87	15.27	14.5	12.3	15.10	14.42	15.4
.798	14.66	15.02	14.79	14.55		14.90	14.21	
.803	14.77	15.12	14.73	14.6	12.2	15.12	14.33	14.9
9271.615	15.02	14.66	15.31	15.4		14.95	14.28	15.6
.619	15.21	14.72	15.53	15.3	12.5	15.17	14.36	15.35
.647	14.97	14.69	15.29	15.3	11.4	15.01	14.23	15.55
.651	15.00	14.77	15.36	15.15	12.5	15.23	14.35	15.55
.697	14.80	14.60	15.32	15.5		15.00	14.07	
.701	14.67	14.89	15.45	15.3	12.6	15.07	14.28	15.15
.722	14.57	14.72	15.42	15.4	11.9	15.01	14.21	15.25
.725	14.75	15.11	15.42	15.15	12.7	15.18	14.32	14.95
.771	14.66	15.11	15.44	15.3		14.89	14.26	15.2
.776					12.5			14.9
.817	14.85	14.97	15.42	15.25	11.5	14.9	13.85	15.1
.820	14.81	15.02	15.35		12.4	14.81	13.87	

TABLE IV

Photographic Magnitudes from Mount Wilson Plates

TABLE IV PHOTOGRAPHIC MAGNITUDES

Plate	Julian Day	No. 1	No. 2	No. 3	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11
3686P	21338.885	14.35	15.45	15.37	15.15?	15.32	14.70	14.63	14.30	15.33
	.887	14.42	15.40	15.23		15.30	14.80	14.73	14.32	15.02
3694P	21339.696	15.53	15.04	15.04	14.90	15.68	15.63	15.23	15.68	14.85
	.699	15.50	14.98	14.85		15.67	15.67	15.17	15.61	14.67
3696P	.719	15.53	14.98	14.98		14.95	15.80	15.23	15.87	14.30
	.721	15.60	14.95	14.95		14.90	15.68	15.22	15.65	14.35
3698P	.740	15.45	15.02	14.87	14.75	14.43	15.67	15.30	15.62	14.18
	.742	15.67	15.07	14.90		14.35	15.62	15.35	15.65	14.23
3699P	.765	15.49	15.18	15.02	14.8	14.03	15.60	15.49	15.57	14.33
	.767	15.63	15.10	14.93		14.02	15.71	15.45	15.76	14.35
3701P	.787	15.48	15.35	15.25	14.9	14.80	15.55	15.53	15.60	14.35
	.789	15.51	15.25	15.14		14.83	15.70	15.44	15.66	14.53
3702P	.807	15.41	15.39	15.32	14.8	14.77	15.78	15.76	15.63	14.45
	.809	15.48		15.15		14.87	15.65	15.77	15.70	14.65
3704P	.828	15.75	15.42	15.09	14.85	14.92	15.62	15.48	15.65	14.69
	.830	15.55	15.36	15.10		14.85	15.55	15.33	15.65	14.80
3705P	.848	15.60	15.47	15.20	14.9	14.97	15.61	15.43	15.66	14.97
	.850	15.59	15.42	15.23		15.06	15.48	15.42	15.75	15.02
3707P	.868	15.45	15.53	15.18	14.9	15.17	15.38	15.42		15.00
	.870	15.47	15.40	15.09		15.13	15.24	15.38		14.97
3708P	.889	15.35	15.53	15.42	15.05	15.25	14.98	15.62	15.85	15.24
	.891	15.55	15.58	15.57		15.37	15.01	15.65	15.95	15.47
3710P	.910	14.76	15.76	15.29	15.05	15.42	14.55	15.42	15.65	15.05
	.912	14.82	15.68	15.25		15.44	14.55	15.32	15.58	15.15
3711P	.932	14.63	15.62	15.43	15.0	15.50	14.57	15.50	15.05	15.01
	.934	14.58	15.51	15.35		15.45	14.60	15.39	14.92	15.21
3713P	.954	14.75	15.60	15.43	14.95	15.55	14.73	15.48	14.75	15.20
	.956	14.75	15.52	15.39		15.40	14.62	15.35	14.70	15.34
3714P	.975	14.85	15.60	15.48	14.95	15.60	14.76	15.55	14.85	15.35
	.977	15.12	15.52	15.47		15.54	14.78	15.56	14.86	15.45
3716P	.993	14.93	15.56	15.48	15.15?	15.54	14.87	15.63	14.99	15.32
	.995	15.06	15.60	15.50		15.48	14.79	15.60	14.99	15.42
3717P	21340.010	15.03	15.60	15.47	15.25	15.46	14.92	15.50	14.90	15.28
	.012	15.14	15.66	15.57		15.66	14.94	15.55	15.00	15.50
3718P	.015	15.10	15.37	15.50	15.25	15.50	15.20	15.57	15.17	15.53
3748P	21375.679	15.62?	15.65	15.50?		15.65?	15.85?	15.85?	15.35?	
	.680	15.56?	15.37	15.37?		15.45?	15.62?	15.85?	15.40?	15.20?
3750P	.695	15.42	15.53	15.03	15.5	15.42	15.53	15.50	15.31	14.97
	.697	15.55	15.56	15.05		15.50	15.52	15.40	15.30	15.26
3751P	.718	15.57	15.65	14.86	15.15	15.40	15.29	15.65	15.92	15.27
	.719	15.63	15.67	14.90		15.55	15.39	15.58	15.90	15.47
3754P	.766	15.30	15.64	15.01	15.3	15.52	15.47	15.10	15.78	15.16
	.768	15.36	15.69	14.93		15.84	15.40	15.14	16.00	15.39
3755P	.790	15.44	15.60	14.80	14.95	15.69	15.76	14.90	15.75	15.47
	.791	15.35	15.58	14.85		15.61	15.61	14.98	15.84	15.77
3757P	.807	15.35	15.35	15.17	15.15	14.99	15.57	14.88	16.00	15.31
	.808	15.57	15.68	15.03		14.92	15.50	14.79	16.00	15.60
3758P	.827				15.25					
	.828									
3760P	.845	15.55	15.72	15.02	15.15	14.37	15.28	14.61	15.81	15.45
	.846	15.57	15.67	15.07		14.58	15.23	14.52	16.05	15.75
3761P	.862	15.71	15.55	15.55	15.15	14.89	15.95	15.13	15.8	15.47

FROM MOUNT WILSON PLATES

No. 12	No. 14	No. 15	No. 16	No. 18	No. 19	No. 20	No. 21	No. 25	No. 28	No. 29	No. 30
15.70	15.20	15.00	14.56	14.67	15.70	14.93	15.60	14.50	14.43	14.90	15.50
15.55	15.20	15.00	14.65	14.80	15.75	14.87	15.75	14.62	14.46	14.91	15.65
15.53	15.41	15.41	14.53	15.63	15.40	15.53	15.06	14.55	15.68	15.02	15.60
15.50	15.40	15.37	14.40	15.51	15.40	15.48	14.87	14.35		14.80	15.68
15.87	15.38	15.25		14.22	15.56	15.45	15.22	14.10	15.64	14.43	15.66
15.73	15.50:	15.25	14.60	14.17	15.48	15.48	15.19	14.08		14.38	15.63
15.69	15.32	15.30	14.85	14.15	15.69	15.35	15.17	14.10	15.71	14.62	15.45
15.52	15.40	15.32	14.92	14.17	15.67	15.10:	15.28	14.10		14.63	15.72
15.75	15.41	15.23	14.96	14.40	15.63	15.40	15.40	14.10	15.65	14.90	15.45
15.77	15.45	15.20	14.97	14.49	15.90	15.40	15.35	14.04		14.86	15.57
15.83	15.17	15.30	15.13	14.80	15.90	15.44	15.72	14.16	15.75	15.08	15.30
15.65	15.17	15.20	14.98	14.75	15.83	15.33	15.58	14.25		15.10	15.34
15.85	15.50	15.18	15.26	14.90	16.05	15.62	15.62	14.02	15.70	15.25	14.99
15.65	15.40	15.10	15.00	14.80	16.00	15.70	15.69	14.15		15.24	15.02
15.80	15.35	14.96	15.03	14.88	15.80	15.58	15.40	14.18	15.60	15.25	14.63
15.72	15.40	14.80	14.88	14.76	15.80	15.47	15.20	14.22		15.25	14.65
15.81	15.42	15.00	15.05	15.02	15.72	15.63	15.40	14.22	15.60	15.38	14.53
15.65	15.48	14.92	15.15	14.98	15.65	15.64	15.31	14.19		15.36	14.60
15.65	15.18	15.02	15.10	15.10	15.75	15.51	15.38	14.32	15.65	15.45	14.65
15.45	15.13	15.00	14.80	14.80	15.55	15.50	15.21	14.22		15.35	14.63
15.81	15.19	15.19	15.19	15.40	15.83	15.60	15.58	14.27	15.75	15.57	14.76
15.73	15.34	15.42	15.15	15.47	15.83	15.58	15.65	14.40		15.54	14.96
15.95	14.90	15.15	15.33	15.47	15.82	15.44:	15.44	14.30	15.25	15.71	14.85
15.68	15.00	15.17	15.13	15.47	15.76	15.48	15.37	14.50		15.68	14.97
15.53	14.77		15.25	15.53	15.77	14.90	15.53	14.36	14.79	15.55	14.95
15.39	14.79	15.42	15.23	15.55	15.78	14.81	15.39	14.39		15.57	15.00
14.73	14.83	15.38	15.40	15.67	15.70	14.65	15.60	14.43	14.48	15.66	14.95
14.52	14.67:	15.25	15.17	15.57	15.75	14.64	15.40	14.38		15.54	14.95
14.44	14.91	15.44	15.52	15.74	15.74	14.55	15.54	14.42	14.60	15.66	15.09
14.30	14.95	15.45	15.32	15.59	15.62		15.41	14.42		15.56	15.01
14.66	14.97	15.52	15.34	15.63	15.26	14.69	15.53	14.50	14.75	15.65	15.08
14.50	15.00	15.45	15.28	15.72	15.08		15.50	14.40		15.65	15.07
14.72	14.98	15.34	15.25	15.70	14.25	14.68	15.53	14.53	14.77	15.59	15.08
14.97	15.06	15.40	15.19	15.72	14.33	14.70	15.54	14.52		15.65	15.18
14.80	15.00	15.45	15.24	15.57	14.30	14.67	15.60	14.57	14.80	15.30	15.20
15.45?	15.48?	15.78?	15.42?	15.75?	16.05?	15.52?	15.90?	14.66	15.85?	15.66?	15.40?
15.24?	15.43?	15.80?	15.20?	15.70?	15.8?			14.50		15.57?	15.30?
15.45	15.19	15.62	15.37	15.58	15.73	15.33	15.40	14.45	15.51	15.66	15.35
15.31	15.30	15.52	15.26	15.60	15.68		15.26	14.43		15.68	15.33
15.80	15.37	15.4	15.27	15.48	15.02	15.48	15.69		15.34	15.76	15.27
5.60	15.60	15.31	15.21	15.55	14.85	15.37	15.53	14.99		15.70	15.36
5.75	15.35	15.50	15.17	15.62	14.45	15.58	15.75	13.75	15.61	15.64	15.43
5.85	15.37	15.29	14.98	15.81	14.29	15.62	15.66	13.87		15.69	15.33
6.05	15.69	15.24	14.53	15.76	14.90	15.72	15.69	13.80	15.85	15.30	15.09
5.97	15.62	15.07	14.59	15.84	14.74	15.77	15.18?	14.07		15.32	15.10
6.00	15.44	15.10	14.60	15.86	14.88	15.65	16.00	14.08	15.35	15.22	15.31
5.85	15.57	15.13	14.29	15.77	14.92	15.61	15.77	13.90		15.16	15.10
			14.21					14.12			
			13.95								
6.05	15.39	14.80	13.80		15.25	15.72	14.90	14.32	14.40	14.64	15.72
5.87	15.50	14.66	13.71		15.05	15.95:	14.60	14.18		14.82	15.52
5.75	15.67		14.07	15.95	15.65	15.47	14.97	14.20	14.83	14.47	15.72

Plate	Julian Day	No. 1	No. 2	No. 3	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11
3761P	21375.863	15.85	15.34	14.95		14.48	15.85	14.92	16.0	15.45
3763P	.886	15.43	15.28	15.24	15.0	14.87	15.56	14.80	15.38	15.96
	.887	15.55	15.47	15.20		14.94	15.43	14.82	15.47	15.88
3764P	.905	14.50	15.68	15.35	14.9	15.35	15.62	14.85	15.70	15.62
	.907	14.81	15.53	15.22		15.40	15.62	14.91	15.62	15.48
3766P	.926	14.38	15.18	15.46	14.85	15.01	15.40	15.20	15.60	15.31
	.928	14.32	15.20	15.42		15.24	15.35	15.22	15.66	15.53
3767P	.946	14.31	15.03	15.40	14.75	15.13	15.09	15.12		15.50
	.948	14.38	14.97	15.45		15.23	15.01	15.26		15.66
3849P	21435.746	15.45	15.62	14.82	14.65?	15.05	15.45	15.35	15.53	14.57

Plate	Julian Day	No. 31	No. 32	No. 33	No. 34	No. 35	No. 38	No. 39	No. 40	No. 41
3686P	21338.885	14.75	15.65	14.55	15.80	14.90	14.6	14.30	15.10	15.58
	.887	14.70	15.75		15.90	14.85		14.37	15.10	15.75
3694P	21339.696	15.43	15.30	15.25	15.88		15.5	15.35	14.83	15.36
	.699	15.43	15.25		15.87	15.19		15.34	14.76	15.27
3696P	.719	15.40	15.43	15.3	15.25	14.90	15.5	15.40	14.90	15.53
	.721	15.32	15.51			15.22		15.43	14.90	15.48
3698P	.740	15.12	15.53	15.4	16.00		15.2	15.48	14.92	15.54
	.742	15.06	15.58		15.88	15.12:		15.50	14.95	15.64
3699P	.765	15.02	15.60	15.5	15.95		14.55	15.52	15.02	15.57
	.767	14.95	15.74		16.05	14.85		15.48	14.95	15.77
3701P	.787	14.97	15.83	15.5	16.05	14.80	14.55	15.57	15.12	15.82
	.789	15.00	15.80		16.05	14.77		15.50	15.04	15.62
3702P	.807	15.01	15.90	15.5	16.05		14.65	15.60	15.30	
	.809	14.83	15.95			14.40		15.55	15.17	15.77
3704P	.828	14.86	15.72	14.9	14.70		14.7	15.48	15.06	15.70
	.830	14.75	15.72			14.60		15.51	15.06	15.62
3705P	.848	14.89	15.66	14.55	14.77		14.75	15.49	15.20	15.53
	.850	14.95	15.67			14.66		15.48	15.10	15.70
3707P	.868	15.00	15.61	14.45	14.80		15.05	15.57	15.15	15.70
	.870	14.96	15.55			14.62		15.42	15.07	15.56
3708P	.889	15.25	15.76	14.45	15.02		14.85	15.53	15.31	15.83
	.891	15.36	15.72			14.88		15.58	15.55	15.95
3710P	.910	15.32	15.70	14.6	15.10		14.9	15.66	15.35	15.82
	.912	15.24	15.62			14.99		15.60	15.20	15.76
3711P	.932	15.43	15.65	14.7	15.13		14.95	15.62	15.24	15.72
	.934	15.39	15.59			14.96		15.57	15.26	15.66
3713P	.954	15.38	15.73	14.95	15.09		15.05	15.57	15.19	15.73
	.956	15.30	15.66			15.04		15.47	15.07	15.68
3714P	.975	15.48	15.67	14.95	15.25		15.15	15.74	15.20	15.74
	.977	15.32	15.56			15.10		15.56	15.15	15.70
3716P	.993	15.35	15.26	14.95	15.35		15.5	15.63	15.00	15.14
	.995	15.30	15.06			15.06		15.61	14.95	15.09
3717P	21340.010	15.27	14.30	15.25	15.12		15.35	15.63	14.85	14.59
	.012	15.28	14.30			15.10		15.57	14.90	14.57
3718P	.015	15.32	14.25	15.35	15.26	15.28	15.05	15.40	15.12	14.60
3748P	21375.679	15.60?	15.90?		15.32?			15.48?	15.48?	14.14?
	.680	15.45?	15.70?			14.91?		15.37?	15.24?	14.17?
3750P	.695	15.45	15.37	15.3	15.05		15.2	15.32	15.07	14.30
	.697	15.44	15.37			14.95		15.40	15.12	14.29
3751P	.718	15.45	14.44	15.5	14.82	14.13	15.4	15.35	15.23	14.44
	.719	15.41	14.33			14.10		15.36	15.27	14.42

No. 12	No. 14	No. 15	No. 16	No. 18	No. 19	No. 20	No. 21	No. 25	No. 28	No. 29	No. 30
15.25	15.53		13.85	16.05	15.70	15.40	14.66	14.09		14.17	15.60
16.05	15.67	14.73	14.22	15.25	15.05	15.19	14.50	14.16	14.55	14.73	15.19
15.80	15.70	14.75	14.15	15.37	15.60	15.26	14.46	14.31		14.65	15.26
16.05	15.30	15.15	14.46	15.20	15.75	15.03	14.46	14.35	14.70	14.70	15.30
16.00	15.40	15.09	14.01	15.35	15.57	14.96	14.65	14.28		14.85	15.57
15.73	15.11	14.70:	14.55	14.10	15.76	14.62	14.88	14.65	15.04	15.13	15.11
15.65	15.15	14.55:	14.20	14.02	15.75	14.49	14.55	14.29		15.06	14.96
15.65	14.81	15.68:	14.47	14.17	15.91	14.45	14.92	14.45	15.12	15.39	14.95
15.42	15.01	15.60:	14.40	14.20	15.89	14.40	15.02	14.45		15.70	14.88
15.70	15.39	14.91	15.13	15.75	15.56	14.89	14.73	14.43	14.82	15.41	14.96

No. 42	No. 43	No. 44	No. 45	No. 47	No. 52	No. 55	No. 58	No. 59	No. 61	No. 62	No. 63
11.7	14.80	15.10	15.22	15.15	14.85		15.53	15.32	15.50	15.32	14.64
11.5	14.80	14.95	15.20	15.30	14.97	15.00	15.50	15.27	15.35	15.20	14.62
11.3	15.32	14.80	14.90		15.10		15.28	14.65	15.10	15.55	15.58
11.3	15.25	14.72	14.79	14.46	15.20	15.67	15.28	14.67	15.00	15.62	15.67
11.4	15.28	14.87	14.56		14.10	15.35:	15.10	14.83	14.73	15.50	15.70
11.3	15.27	14.90	14.55	14.40	13.90	15.32	15.10	14.92	14.68	15.50	15.65
11.4	15.29	14.75	14.26	14.09	14.10		15.30	14.82	14.53	15.38	15.69
	15.35	14.96	14.28	14.51	14.05	15.45	15.26	14.93	14.60	15.27	15.82
11.4	15.37	14.88	14.23:		14.20		15.40		14.75	15.27	15.72
11.4	15.42	14.93	14.17	14.53	14.30	15.28	15.28	14.95	14.64	14.90	16.05
11.5	15.32	14.92:	14.10:		14.46		15.72		14.90	15.04	15.85
11.5	15.36	15.10	14.23	14.61	14.65	15.26	15.55	15.15	14.85	15.07	15.85
11.4	15.45	14.95	14.05		14.35		15.72		14.91	14.77	15.95
11.5	15.35	14.98	14.20	14.78	14.26	15.18	15.57	15.20	14.89	14.95	16.05
11.5	15.49	15.22	14.58	14.85	14.63		15.63	15.40	15.10	14.90	15.70
	15.40	15.17	14.65	14.88	14.66	14.85	15.55	15.36	15.10	14.83	15.80
11.6	15.60	15.27	14.92		14.66		15.65	15.27	15.20	15.00	15.19
	15.53	15.18	14.77	15.03	14.76	14.86	15.60	15.31	15.20	14.95	15.31
11.6	15.50	15.00	14.66		14.80		15.65	15.07	15.17	15.05	15.17
	15.55	14.83	14.62	14.83	14.75	14.80	15.59	15.25	15.17	14.98	15.00
11.7	15.67	15.08	14.96		14.83		15.73	15.58	15.31	15.22	14.85
11.8	15.68	15.17	15.21	15.51	15.17	14.88	15.75	15.63	15.50	15.40	15.03
11.8	15.67	14.79	14.82	15.06	14.94		15.85	15.20	15.40	15.24	14.30
	15.57	14.80	14.75		14.97	15.00		15.35	15.40	15.32	14.39
11.7	15.53	14.79	14.75		15.00		15.82	15.26	15.38	15.41	14.54
	15.50	14.75	14.89	15.12	15.25	15.01	15.74	15.32	15.45	15.51	14.58
11.7	15.57	14.75	14.87		15.14		15.78	15.27	15.45	15.48	14.65
	15.54	14.74	14.95	15.26	15.20	15.18	15.62	15.38	15.45	15.45	14.72
1.7	15.62		15.05		15.30		15.86	15.34	15.50	15.40	14.87
	15.61	14.70	15.12	15.33	15.09	15.41	15.77	15.36	15.47	15.27	14.89
1.7	15.67	14.69	15.14		15.35		15.79	15.19	15.48	15.34	15.07
	15.70	14.65	15.04	15.32	15.39	15.25	15.79	15.37	15.60	15.30	14.97
1.7	15.60	14.92	15.19		15.15		15.60	15.52	15.60	15.18	15.00
	15.69	14.90	15.23	15.27	15.34	15.29	15.60	15.60	15.57	15.25	15.06
1.8	15.55	14.98	15.06	15.30	15.17	15.25	15.49	15.25	15.37	15.26	15.17
2.2?	15.75?	14.89?					15.80?		15.17?	15.75?	15.60
	15.70?	14.92?		15.15?		15.20?	15.56?		15.16?	15.70?	15.40
2.1	15.63	14.80	14.60		15.20		15.75	15.10	15.16	15.49	14.84
	15.56	14.95	14.65	15.07	15.25	14.89	15.55		15.15	15.52	15.02
2.3	15.63	15.18			14.86		15.85		15.33	15.42	14.52
	15.69	15.17	15.03	15.43	15.17	14.88	15.90	15.53	15.46	15.47	14.62

Plate	Julian Day	No. 31	No. 32	No. 33	No. 34	No. 35	No. 38	No. 39	No. 40	No. 41
3754P	21375.766	15.50	14.57	15.55	14.71		15.35	15.53	15.27	14.88
	.768	15.33	14.62			14.90		15.55	15.31	14.87
3755P	.790	15.44	14.95	15.4	14.98		15.3	15.40	15.10	15.10
	.791	15.35	14.98			15.19		15.35	15.25	14.97
3757P	.807	15.03	14.91	15.6	15.06		15.2	15.40	15.21	15.10
	.808	14.95	14.88			14.98		15.35	15.30	15.10
3758P	.827			15.25			15.3			
3760P	.845	14.85	15.17	15.3	14.90		15.3	15.57	15.22	15.22
	.846	14.75	15.08			14.70		15.38	15.23	15.23
3761P	.862	15.07	15.35	15.25	15.35		15.15	15.75	15.13	15.68
	.863	14.72	15.58			14.40		15.62	14.91	15.30
3763P	.886	14.85	14.90	15.25	15.24		15.3	15.25	14.73	15.58
	.887	14.72	15.07			14.59		15.26	14.82	15.70
3764P	.905	14.97	15.66	15.5	15.10		15.25	15.86	14.80	15.27
	.907	15.03	15.79			14.82		15.70	14.71	15.31
3766P	.926	15.23	15.67	15.2	15.23		15.4	15.76	15.05	15.68
	.928	15.21	15.85			14.80		15.69	14.92	15.75
3767P	.946	15.20	15.82	14.7	15.27		15.3	15.85	14.92	15.82
	.948	15.37	15.75			14.91		15.67	15.01	15.65
3849P	21435.746	15.03	14.62	14.95	14.57	15.07	14.4	15.25	15.34	15.35

Plate	Julian Day	No. 64	No. 65	No. 66	No. 67	No. 68	No. 69	No. 70	No. 71	No. 72
3686P	21338.885	15.45	14.43	15.20	14.5	15.65		15.70	15.80	15.55
	.887	15.25	14.57	15.12		15.75		15.50	15.90	15.50
3694P	21339.696	15.53	15.38	15.07	15.75?	15.27		14.85	15.41	15.80
	.699	15.52	15.41	14.93		15.22		14.67	15.43	15.72
3696P	.719	15.76	15.65	14.98	15.5	15.15	16.05	14.62	15.66	15.77
	.721	15.67	15.58	15.02		15.13	15.87	14.50	15.57	15.67
3698P	.740	15.69	15.39	15.01	15.35	15.00	14.93?	14.70	15.67	15.33
	.742	15.62	15.45	14.92		15.02	14.88?	14.80	15.70	15.43
3699P	.765	15.65	15.45	15.08	15.25	15.33	14.32	15.11	15.77	15.29
	.767	15.75	15.50	15.02		15.28	14.26	15.02	16.00	15.28
3701P	.787	15.87	15.34	15.15	14.9	15.22	14.40	15.20	15.20	15.32
	.789	15.62	15.30	15.13		15.35	14.49	15.16	15.16	15.26
3702P	.807	15.74	14.94	15.58	14.55	15.48	14.90	15.57	15.57	15.37
	.809	15.62	15.07	15.48		15.61	14.92	15.53	15.53	15.30
3704P	.828	15.70	14.70	15.30	14.45	15.35	14.76	15.18	15.18	15.03
	.830	15.45	14.77	15.29		15.22	14.62	15.22	15.22	14.86
3705P	.848	15.55	14.90	15.33	14.55	15.37	14.87	15.28	15.28	15.00
	.850	15.44	14.90	15.27		15.44	14.90	15.27	15.27	14.95
3707P	.868	15.55	14.53	15.40	14.45	15.58	15.07	15.30	15.83	15.12
	.870	15.35	14.75	15.37		15.50	14.89	15.25	15.72	14.93
3708P	.889	15.58	14.76		14.55	15.85	15.46	15.71	16.05	15.35
	.891	15.60	15.10			15.75	15.40	15.72	15.95	15.36
3710P	.910	15.87	15.20	15.44	14.8	15.58	15.04	15.34	15.70	15.00
	.912	15.69	15.10	15.47		15.62	15.15	15.36	15.70	15.10
3711P	.932	15.76	15.20	15.52	14.9	15.58	15.47	15.53	15.25	15.15
	.934	15.66	15.25	15.47		15.57	15.33	15.58	15.66	15.10
3713P	.954	15.66	15.28	15.55	15.0	15.55	15.63	15.63	15.73	15.15
	.956	15.43	15.00	15.45		15.50	15.52	15.54	15.77	15.14
3714P	.975	15.26	15.40	15.44	15.25	15.65	15.55	15.53	15.85	15.25
	.977	15.05	15.34	15.45		15.47	15.45	15.47	15.76	15.14
3716P	.993	14.74	15.26	15.28	15.25	15.45	15.60	15.50	15.70	15.17

No. 42	No. 43	No. 44	No. 45	No. 47	No. 52	No. 55	No. 58	No. 59	No. 61	No. 62	No. 63
12.2	15.25	14.75			14.95	15.30	15.83		15.62	15.19	14.89
	15.14	14.75	14.75	15.02	15.17	15.22	15.95	15.45	15.69	15.28	15.08
12.6	15.09	15.32	15.35:		15.17		15.50		15.72	14.63	14.93
	15.02	15.42	15.40:	15.65	15.33	15.18	15.50	15.65	15.76	14.85	15.13
12.4	14.91		15.37		15.26		15.41		15.73	15.07	15.21
	14.77	15.16	15.52	15.49	15.13	15.30	15.75	15.75	15.68	14.83	15.02
12.4										14.40	
12.3	15.00	14.82	15.45	14.85	14.00		15.51		15.79	14.85	15.06
	15.00	14.90	15.60		13.92	15.23	15.61	15.90	15.90	14.90	15.08
12.2	15.13	14.10	15.35		13.75		15.80		15.55	15.55	15.65
	14.85	14.29	15.12	14.05	13.88	15.45	15.68	15.10	15.30	15.40	15.49
12.5	15.25	15.05	16.05	14.52	13.93		15.52		15.85	14.94	15.10
	15.19	15.15	15.75		14.07	15.10	15.53	15.63	15.60	15.10	15.19
12.4	14.77	15.41	15.20		13.72		14.85		16.05	15.55	15.48
	14.65	15.13	15.52	14.30	13.95	15.62	15.22	15.53	16.0	15.31	15.40
12.3	15.07	14.40	15.13		14.57		15.51		15.53	15.42	15.60
	15.21	14.39	15.20		14.52	15.57	15.42	14.26	15.75	15.56	15.78
12.1	15.12	14.33	15.07		14.50		14.78		15.70	15.68	15.75
	15.20	14.54	15.23	14.40	14.62	15.48	14.60	14.34	15.69	15.82	15.90
12.9	15.28	15.26	15.23	15.10	15.07		15.64:	15.16	15.68	14.91	15.42

No. 73	No. 74	No. 75	No. 76	No. 77	No. 78	No. 79	No. 80	No. 81	No. 83	No. 87	No. 92
14.46	13.62	15.33	15.33	15.32	15.15	14.75	15.07		15.45	15.15	
14.52	13.55	15.25	15.23	15.20	15.10	14.75	15.13	14.82	15.43	15.27	
15.03	14.25	15.03	15.32	15.35	15.20	15.03			14.90	15.23	14.05
15.00	14.15	15.08	15.27	15.37	15.17	14.92	14.70	15.45	14.70	15.17	14.00
15.14	14.16	15.08	15.23	15.32	15.03	15.02			14.70	15.15	14.01
15.25	14.13	15.10	15.28	15.38	15.02	15.23	14.45	15.57	14.82	15.15	
15.30	13.81	15.08	15.27	15.35	14.95	14.87			14.50	15.25	14.10
15.38	13.81	15.18	15.32	15.45	14.95	14.96	14.86	15.52	14.45	15.45	
15.45	13.60	15.23	15.28	15.37	14.90				14.70	15.17	14.22
15.43	13.63	15.17	15.35	15.35	14.83	14.92	14.92	15.38	14.62	15.26	14.18
15.46	13.85	15.35	15.32	15.40	15.00	15.05			14.75	15.17	14.25
15.42	13.85	15.26	15.32	15.45	14.97		15.00	15.30	14.65	15.11	14.17
15.57	14.04	15.37	15.10	15.57	14.96	14.74			14.80	14.96	14.0
15.57	14.00	15.30	15.17	15.45	15.05	15.06	15.05	15.46	14.80	14.83	
15.35	13.93	14.89	14.86	15.36	15.11	15.05			15.07	14.70	14.27
15.30	14.00	15.12	14.85	15.30	15.07	14.95	15.33	15.33	14.77	14.80	14.18
15.30	13.97	15.19	14.75	15.19	15.25	14.91			15.00	14.65	14.21
15.25	14.01	15.23	14.85	15.39	15.25	14.89	15.22	15.31	14.95	14.85	14.15
15.12	13.95	15.25	14.79	15.24	15.30	14.67			15.00	14.74	14.36
15.05	14.00	15.17	14.77	15.28	15.16	14.75	14.98	15.30	14.87	14.75	14.13
14.98	14.23	15.42	14.67	15.13	15.56	14.70			15.13	14.71	14.12
15.20	14.35	15.38	14.86	15.38	15.65	14.92	15.45	15.25	15.12	15.08	14.23
14.98	13.95	15.37	14.72	15.10	15.58	14.57			15.19	14.76	14.15
14.95	14.08	15.42	14.79	15.15	15.50	14.80	15.05	14.95		14.95	14.30
14.84	14.18	15.50	14.69	14.82	15.43	14.79			15.27	14.73	14.20
14.80	14.22	15.39?	14.70	14.89	15.39	14.58	15.01	14.43		14.89	14.20
14.92	14.21	15.38	14.59	14.69	15.30	14.65			15.36	14.75	14.23
14.80	14.19	15.34	14.58	14.77	15.32	14.78	14.96	14.52		14.85	14.37
14.79	14.19	15.42	14.60	14.65	15.31				15.29	14.91	14.10
14.95	14.25	15.34	14.57	14.75	15.32	14.84	14.90	14.63		14.98	
14.93	14.25	15.36	14.65	14.55	15.17	14.89			15.39	14.97	14.10

Plate	Julian Day	No. 64	No. 65	No. 66	No. 67	No. 68	No. 69	No. 70	No. 71	No. 72
3716P	21339.995	14.64	15.35	15.25		15.28	15.60	15.48	15.70	15.19
3717P	21340.010		15.45	15.10	15.3	15.10	15.67	15.55	15.70	15.16
	.012	14.40	15.38	15.05		15.15	15.58	15.60	15.48	15.28
3718P	.015	14.52	15.23	15.35	15.5	15.10	15.65	15.75	15.47	15.37
3748P	21375.679	15.73		15.70	14.9?	16.0?		15.80	15.90?	15.95
	.680	15.39		15.50		15.66?		15.54	15.80?	15.80
3750P	.695	15.51	15.73	15.65	15.05	15.65	16.00	15.80	15.13	15.65
	.697	15.47	15.65	15.60		15.70	16.00	15.85	15.15	15.80
3751P	.718	15.46	15.76	15.66	15.05	15.52	16.05	16.00	14.36	15.35
	.719	15.35	15.82	15.81		15.53	16.05	15.92	14.50	15.44
3754P	.766	15.75	15.64	15.12	14.55	15.12	15.85	15.79	14.50	14.33
	.768	15.59	15.45	14.96		15.05	16.05	15.95	14.41	14.27
3755P	.790	15.43	15.72	15.09	14.55	14.75	15.85	15.85	14.58	14.40
	.791	15.25	15.80	15.05		15.02	15.80	15.80	14.79	14.50
3757P	.807	15.35	15.84	15.03	14.5	15.40	16.05	16.05	15.31	14.91
	.808	15.35	15.60	15.13		15.35	16.05	15.95	15.30	15.16
3758P	.827				14.35					
3760P	.845	15.67	15.75	14.85	14.45	14.93	15.65	15.55	15.22	14.85
	.846	15.53	15.45	14.90		14.79	15.83	15.50	15.08	14.88
3761P	.862	15.68	14.70	15.08	14.7	14.73	14.95	15.85	15.60	15.05
	.863	15.40	14.58			14.76	14.53	15.63	15.25	15.25
3763P	.886	15.70	14.35	14.95	15.1?	14.67	13.70	15.75	15.10	15.02
	.887	15.32	14.39	14.77		14.77	13.85	15.60	15.19	15.00
3764P	.905	15.85	14.45	14.67	15.15	14.90	13.90	15.95	16.00	15.70
	.907	15.53	14.65	15.02		15.21	13.85	15.62	15.67	15.48
3766P	.926	15.17	14.95	15.13	15.25	14.85	13.93	15.79	15.60	15.31
	.928	14.96	14.67	15.14		15.12	13.90	15.78	15.72	15.35
3767P	.946	14.56	14.53	15.30	15.25	15.60	14.53	15.97	16.15	15.71
	.948	14.59	14.62	15.30		15.64	14.45	15.82	16.0	15.73
3849P	21435.746		15.41?	15.07				15.19		

No. 73	No. 74	No. 75	No. 76	No. 77	No. 78	No. 79	No. 80	No. 81	No. 83	No. 87	No. 92
14.90	14.16	15.42	14.53	14.60	15.05	14.84	14.91	14.57		15.11	13.93
14.85	14.24	15.32	14.53	14.49	14.99	15.02			15.37	14.81	14.06
14.82	14.35	15.32	14.72	14.63	15.05	15.00	14.94	14.63		14.98	14.15
15.20	14.40	15.30	14.60	14.60	15.25	14.87	15.10	14.82		15.25	14.17
15.15?	13.93?	15.66?	15.43?	14.88?	15.52?				14.98		14.32
14.93?	14.10?	15.50?	15.30?	14.91?	15.32?		14.70	15.12?		15.70?	14.10
14.88	13.88	15.42	15.10	14.89	15.15	14.90			14.69	15.25	14.35
14.93	13.78	15.47	15.12	14.95	15.24		14.70	14.83		15.35	14.20
15.07	13.79	15.40	14.88	14.84	15.16	15.00			14.47	14.89	14.07
15.12	13.88	15.39	15.04	14.90	15.30		14.85	14.57		15.09	14.05
15.17	13.75	15.50	15.04	15.01	14.75	14.85			14.95	15.25	13.43
15.40	13.90	15.45	15.00	15.05	14.87		14.69	14.79		15.32	13.39
15.21	13.60	15.43	14.80	14.90	14.98	14.90			15.55	15.25	13.52
15.19	13.90	15.45	14.94	15.02	14.86		15.22	15.02		15.02	13.48
15.50	14.05	15.65	14.80	15.25	14.88	14.83			15.35	15.21	13.59
15.57	14.00	15.61	14.75	15.10	15.25		15.10	15.91		15.02	13.53
	14.17		14.23								13.77
15.40	13.95	15.47	14.77	15.22	15.00	14.70			15.48	15.05	13.79
15.32	14.01	15.45	14.72	15.17	15.18		15.23	15.17		15.00	13.80
15.40	14.25	15.80	14.78	15.17	15.60				15.29	15.84	13.86
15.17	14.15	15.61	14.85	15.10	15.33		14.72	15.53		16.00	
15.15	14.00	15.15	14.51	15.05	15.44	14.67			15.85	14.87	14.00
15.19	14.18	15.20	14.69	15.03	15.27		15.56	15.46		15.07	14.07
	13.95	15.02	14.85	15.15	15.20				16.05	15.21	14.0
	13.88	15.45	15.03	15.35	15.21		15.27	15.70		15.40	
15.00	14.13	15.18	15.18	15.28	15.25	14.54			15.28	15.35	14.00
	14.17	15.12	15.12	15.42	15.50		14.83	15.18		15.66	14.02
	14.21	15.17	15.18	15.30	15.27	14.63			15.52	15.33	14.15
	14.25	15.17	15.23	15.41	15.48		14.67	15.33		15.53	14.02
15.28	14.08	15.20	15.10	14.91	15.28	15.23	15.16	15.41	15.53	15.05	14.13

plates published by Bailey (1917) and from 81 by Oosterhoff (1941) were used to investigate the period changes of the RR Lyrae stars in M5.

The reciprocal periods given by Oosterhoff (1941) were used in determining the light curves. The phases for the light curves were computed from the formula:

$$\text{phase} = \frac{\text{Julian Date of Observation} - 2400000}{P}.$$

Separate light curves were plotted for the following epochs: 1889, 1895–96, 1897–99, 1901–02, 1904–05, 1908, 1912, 1917, 1934–35, 1936–38, 1940–42, 1943–44, 1946–49, 1950–53, 1954–56, 1959–60, 1963–64, 1966. Figure 5 shows the light curves of variable 7 at the various epochs. The light curve for each variable given by the 1934–35 observations of Oosterhoff was drawn on tracing paper. Each was then fitted to the other curves by a horizontal shift. Thus the phase-shifts relative to the epoch 1934–35 were determined. (A positive phase-shift implies that the features on the light curve in question occur at later

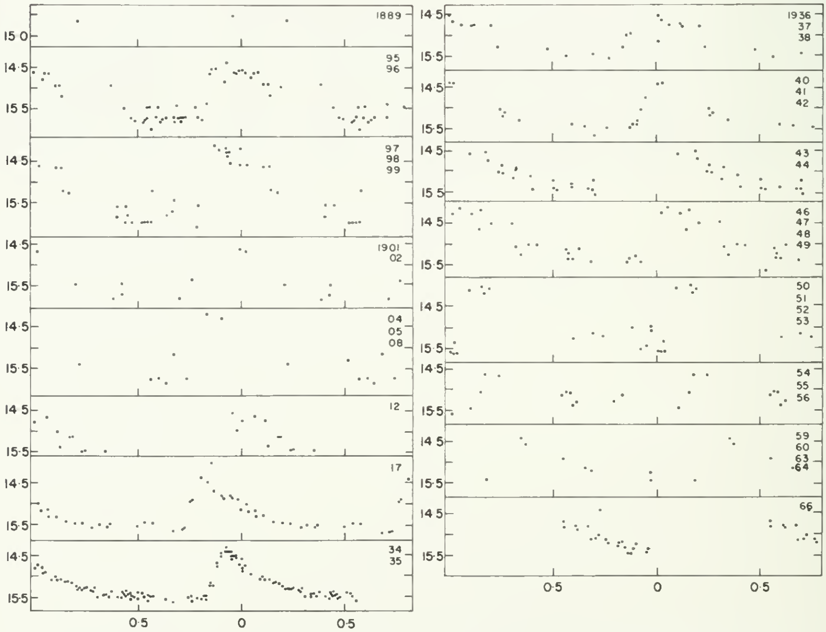

FIG. 5—Illustration of light curves for determination of phase-shift diagram (variable 7).

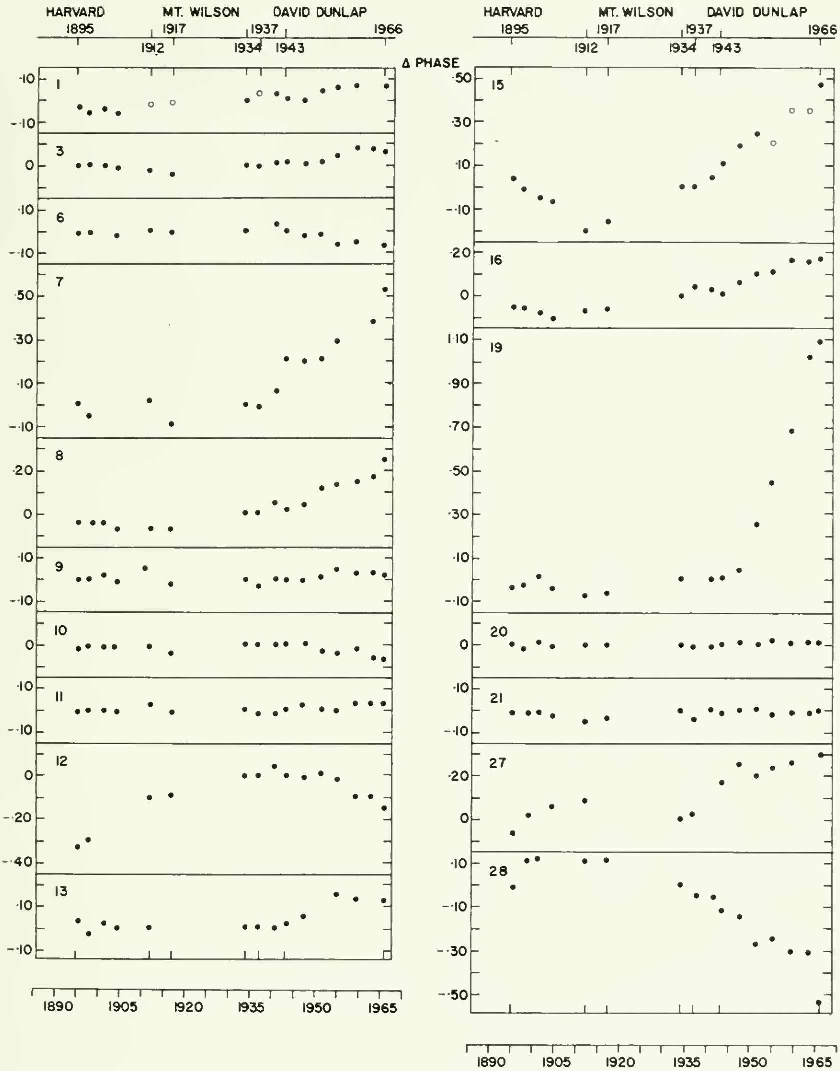

FIG. 6—Phase-shift diagrams (phase-shift in fraction of a period).

phases than on the 1934–35 curve.) Then a phase-shift diagram was plotted.

No phase-shift diagrams were plotted for variables 2, 14, 18, 25, 35, 44, 52, 58, 65, 66, 67, 68, 72, and 92 because their light curves were too irregular. The phase-shifts for the other 52 stars are listed in Table II and their phase-shift diagrams are shown in figure 6.

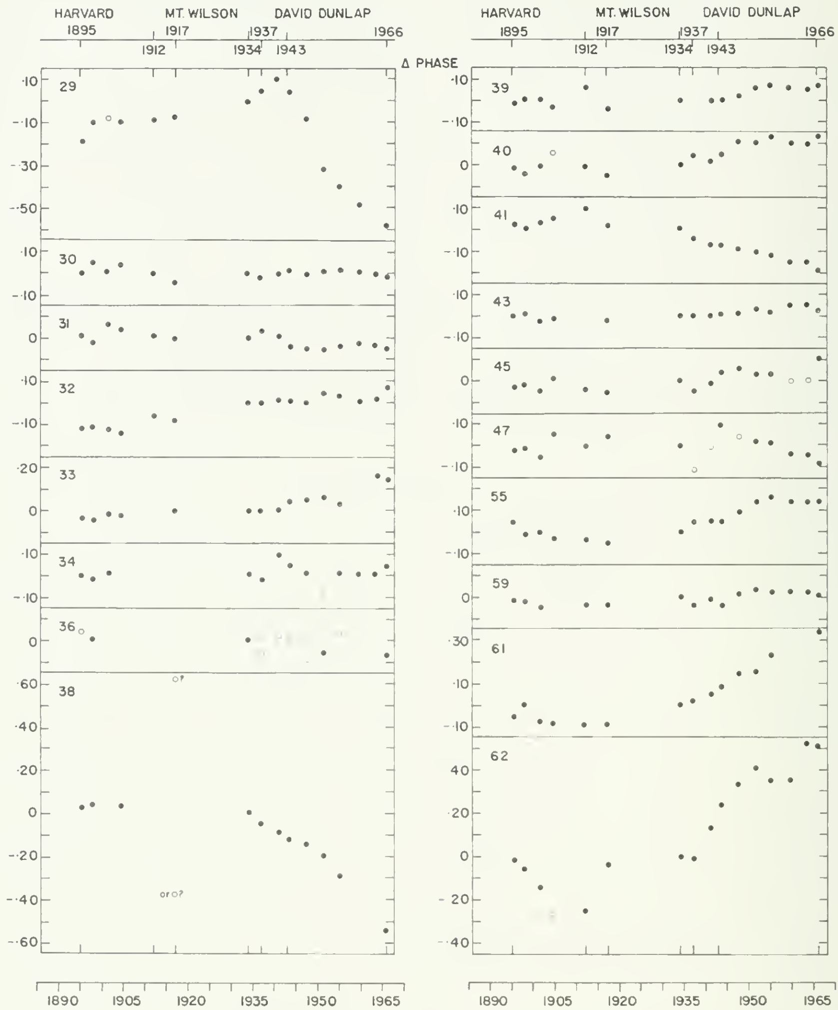

FIG. 6—Phase-shift diagrams (continued).

Determination of Period Changes

The changes of period have been determined in two ways: by fitting parabolas to the points on the phase-shift diagrams to determine the rate of period change, β, and by fitting intersecting straight lines to the points to determine the amount of period change, ΔP.

Standard parabolas were plotted on transparent paper for 11 values

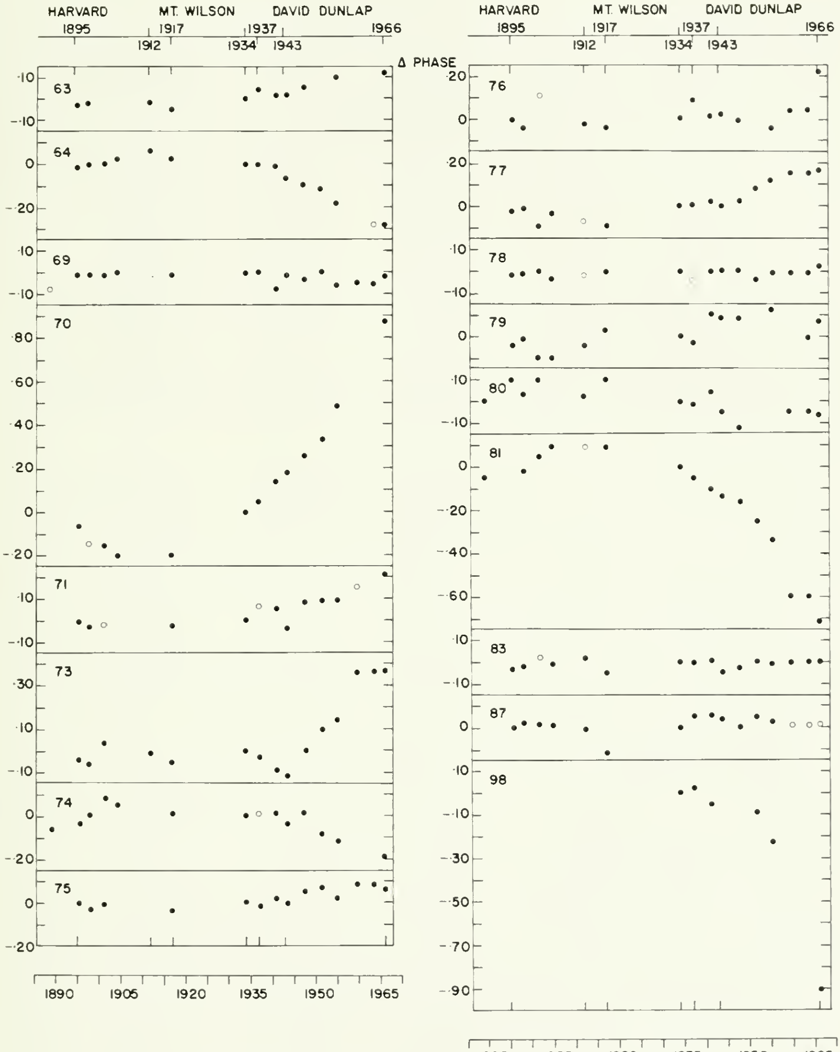

FIG. 6—Phase-shift diagrams (continued).

of $\beta/2P^2$ between 10^{-10} and 10^{-8} days^{-2}. These were fitted visually to the phase-shift diagrams and the values of β computed for each star from the most suitable parabola. Most of the phase-shift diagrams are not true parabolas and there is an uncertainty of about 25 per cent in the values of β.

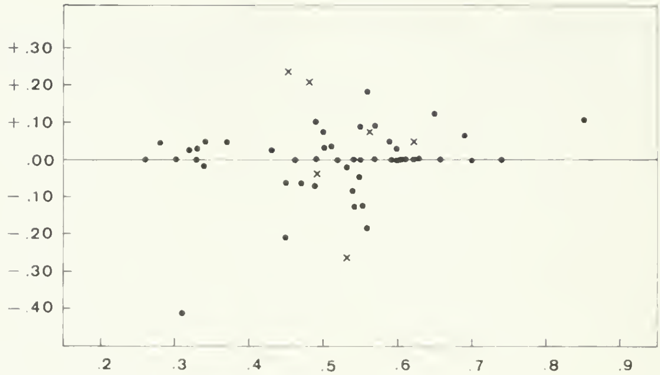

FIG. 7—The rate of change of period, β (in days per million years) determined from fitting parabolas to the points in the phase-shift diagrams, plotted against the period (in days), stars with constant period included.

An attempt was made to determine the amount of this change in a million years in order to compare with the values of β determined from the parabolas. Of the 50 stars for which the period increased, decreased or remained constant during the seventy-year interval, periods of 18 (or about one-third) remained constant. Then, if the interval of observations was extended to 100 years, it might be expected that abrupt changes in the periods of these stars would be observed, i.e., a star changes its period abruptly about once in 100 years. At this rate, in a million years, the period of a star would change by 10,000 times the amount observed in 70 years. Assuming this, the period change expected in a million years is calculated for those stars for which changes were observed in the present investigation. These are listed in Table V and plotted against period in figure 8.

If the phase-shift diagram produced a single straight line, the period was assumed constant and corrected if necessary: ΔP (correction to period) = slope $\times$ P^2. These corrected periods are listed in Table V. The light curves for these stars are shown in figure 9.

In Table V the epochs are those given by Oosterhoff in heliocentric Julian days with the first two digits (24) omitted. Successive columns give the period, reciprocal period, β (the rate of change of period in days per million years), and the projected period change for a million years (assuming the period changes abruptly). The periods adopted here are those computed from Oosterhoff's reciprocal periods. It was found in the course of this investigation that Oosterhoff's periods do not always correspond to his reciprocals. Besides the stars with period

TABLE V

PERIODS OF VARIABLES IN M5

Var.	Epoch from Oosterhoff	Period days	Reciprocal Period	β days/ 10^6 yr	Rate abrupt change	Notes
1	27563.794	0.5217856	1.916496			const.
2	27601.700	0.526				1
3	27567.842	0.6001832	1.666158	.039	.044	
4	27627.708	0.4496402	2.224006	.234:		15
6	27567.856	0.5488311	1.822054	−.048	−.026	
7	27601.730	0.4943896	2.0226962	.105	.100	
8	27605.697	0.54623	1.83075	.091	.077	
9	27653.855	0.6988950	1.43083			const.
10	27567.825	0.5306628	1.8844359	−.020	−.037	
11	27563.817	0.5958914	1.678158			const.
12	27601.762	0.4677144	2.138057	−.064	−.096	
13	27567.800	0.5131223	1.948853	.038	.046	
14	27567.974	0.4872423	2.052367			1
15	27567.908	0.3367607	2.969468	.050	.084	
16	27567.781	0.6476223	1.54411	.124	.069	
18	27567.773	0.464	2.15573			1
19	27601.706	0.4699535	2.12787		.374	2
20	27601.729	0.6094759	1.640754			const.
21	27605.684	0.6048941	1.653182			const.
24	27567.821	0.4783771	2.090401	.205		15
25	27567.766	0.508	1.969			3
26	27601.761	0.6225642	1.60626	.044		15
27	27888.894	0.4703	2.126217			4
28	27540.882	0.5439474	1.838413	−.127	−.292	5
29	27567.700	0.4514355	2.215166	−.120	−.180	6
30	27567.761	0.5921755	1.6886886			const.
31	27567.872	0.3005826	3.3268725			const.
32	27605.754	0.4577863	2.1844254			const.
33	27601.738	0.5014722	1.9941286	.037	.041	7
34	27567.727	0.5681431	1.76012			const.
35	27567.866	0.3081197	3.245492			1
36	27563.868	0.6277229	1.5930596			const.
37	27605.762	0.4887941	2.045851	−.039		15
38	27889.937	0.4704441	2.1256511			
39	27563.832	0.5890346	1.697693	.051	.035	
40	27605.698	0.3173286	3.1513078	.029	.015	
41	27567.879	0.4885749	2.046769	−.070	−.072	
43	27601.767	0.6602264	1.514632			const.
44	27601.732	0.329	3.0362			10
45	27567.774	0.6166364	1.6217012			const.
47	27563.861	0.5397295	1.85278	−.085	−.077	
52	27563.804	0.5017848	1.992886			1
55	27601.734	0.3288968	3.040467	.032	.028	
56	27889.931	0.5346903	1.8702415	−.264		15
58	27601.716	0.491265	2.03556			1
59	27540.936	0.5420259	1.8449303			const.
61	27567.826	0.5686157	1.758657	.095	.107	
62	27601.704	0.2814092	3.553544		.193	11
63	27567.851	0.4976763	2.009338	.037	.031	
64	27540.853	0.5445075	1.836522	−.127	−.117	
65	27628.729	0.480691	2.08034			12
66	27567.813	0.350681	2.85159			13
67	27567.733	0.3490462	2.86495			13

TABLE V—*continued*

Var.	Epoch from Oosterhoff	Period	Reciprocal Period	β days 10^6 yr	Rate for abrupt change	Notes
68	27628.727	0.3342797	2.991507			13
69	27567.761	0.4948743	2.0207151			const.
70	27567.930	0.5585255	1.7904286	.184	.268	
71	27541.011	0.5024676	1.990178	.073	.039	
72	27596.82	0.562	1.779			1
73	27601.753	0.3401118	2.94021	.050	.074	
74	27626.684	0.4539961	2.202662	−.060	−.048	
75	27596.816	0.6854136	1.458973	.070	.057	
76	27563.813	0.4324210	2.312561	.027	.118	
77	27605.721	0.8451121	1.183275	.106	.176	
78	27567.727	0.2648174	3.776187			const.
79	27567.884	0.3331387	3.001753			const.
80	27562.986	0.3365424	2.9713936	−.017	−.014	
81	27567.972	0.5573235	1.79429	−.184	−.265	
83	27567.783	0.5533073	1.807314			const.
87	27540.914	0.7383888	1.3543			const.
90	27540.828	0.5571527	1.79484	.076		15
92	27567.963	0.4635789	2.15713			14
98	27605.737	0.3063857	3.26386	−.416	−.060	

NOTES

1. Irregular; therefore no phase-shift diagram was plotted.
2. No parabola could be fitted on the phase-shift diagram. Period changes abruptly between 1945 and 1950.
3. Following component of close double. Of Oosterhoff's two possible periods, 0.508 and 0.517 days, the D.D.O. observations fit the former, but not well enough for a phase-shift diagram.
4. Irregular, Oosterhoff. A complicated phase-shift diagram indicates a fluctuating period.
5. Period change calculated from difference in slope between first and third line of three straight lines.
6. Oosterhoff found the shape of the light curves abnormal for the period, with rising branch less steep than expected.
7. Visual observations by Barnard (1909). His published Julian Dates appear to be calculated for noon C.S.T. On this assumption, his light curves coincide with those of Bailey (1917).
8. Irregular Oosterhoff, and current investigation. Bailey class *c*, and no phase-shift diagram made.
9. Phase of light curve in 1917 ambiguous with respect to the others, which prevents definite determination of period change.
10. Period irregular. The D.D.O. observations fit Oosterhoff's longer period of 0.329 better than his 0.247-day period.
11. Positions of light curves from observations of Bailey in 1912 and Shapley in 1917 ambiguous, relative to other years. Net change in period calculated from slope of line representing Bailey's observations and that for D.D.O. observations.
12. Probably not irregular, but because of uncertainties in measures due to closeness to another star no phase-shift diagram was constructed.
13. Bailey class *c*, some irregularity, no phase-shift diagram.
14. Measures difficult on D.D.O. plates; perhaps irregular.
15. β determined by Oosterhoff.

changes, the table lists those with constant or irregular periods, and six stars for which Oosterhoff (1941) found period changes, but which were not studied on the David Dunlap plates.

Discussion

From this study of the variables in M5 with observations over an interval of 75 years, we have found that for 18 stars the periods are constant, for 20 they have increased, and for 12 they have decreased.

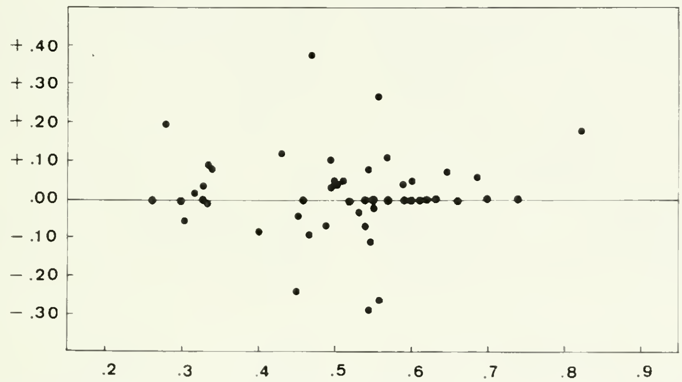

FIG. 8—The projected period change (in days per million years) determined from fitting straight lines to the points in the phase-shift diagrams, including stars with constant period.

For the other 16 stars, periods are not well determined or are irregular. The median rate of change of period for the stars with increasing periods is 0.05 ($\pm$0.02) days per million years; the median rate for those decreasing is 0.075 ($\pm$0.02) days per million years. The median rate of change of periods of all the stars considered together is zero. It is interesting to try to determine if these changes are due to evolution of the stars across the horizontal branch of the H-R diagram or if they are just random. If the former, then it follows that both the decreases and the increases must have evolutionary significance. Otherwise, since the median rate of period change is zero, the changes do not indicate an evolutionary trend.

Sandage (1957) has calculated, by semi-empirical methods, a time scale for stars in the RR Lyrae phase in M3. According to him, the stars spend 8×10^7 years in the RR Lyrae stage. The H-R diagram for M5 is very similar to that of M3, and so, it might be concluded that stars in M5 also spend about 8×10^7 years in the RR Lyrae stage. According to figure 10, the range of periods an RR Lyrae star in M5

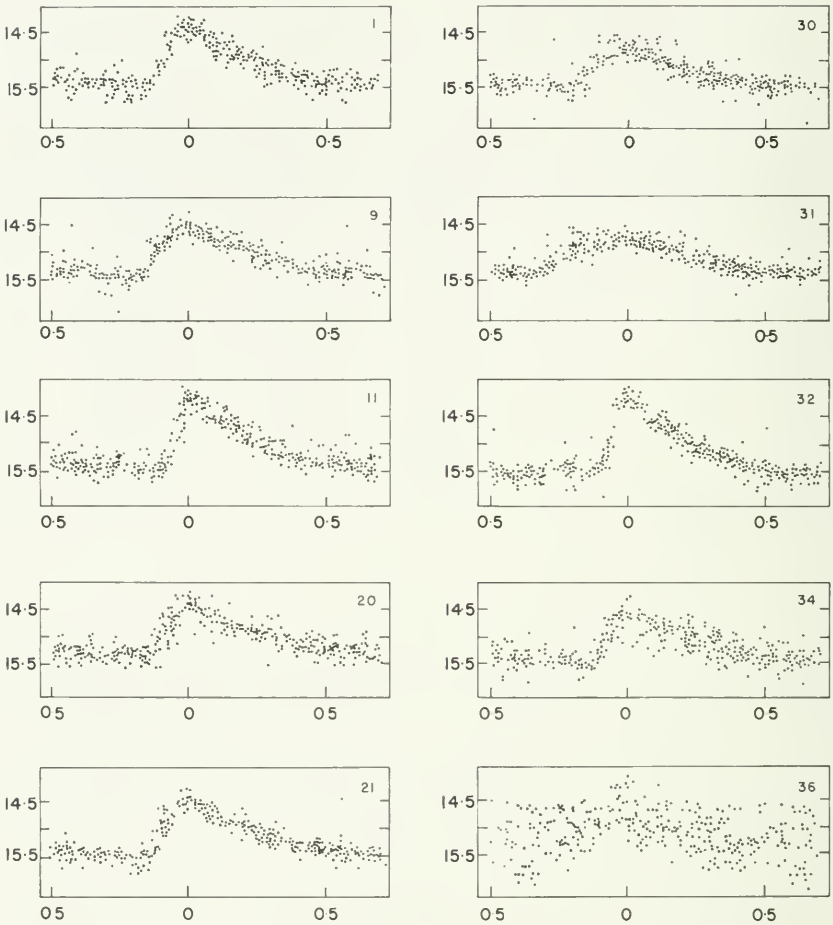

Fig. 9—Light curves for stars with constant periods.

may take is 0.55 days (allowing for a gap between types *c* and *a*). Thus the expected average rate of change in period is 0.007 days per million years. The minimum rate that can be detected over 75 years depends on the period. The minimum value of $\beta/2P^2$ observable at the present time is 10^{-10} days^{-2}. This corresponds to the following values for β:

$$
\begin{aligned}
\beta &= 0.04 \text{ days per million years for } P = 0.8 \text{ days},\\
&= 0.02 \text{ days per million years for } P = 0.5,\\
&= 0.005 \text{ days per million years for } P = 0.25.
\end{aligned}
$$

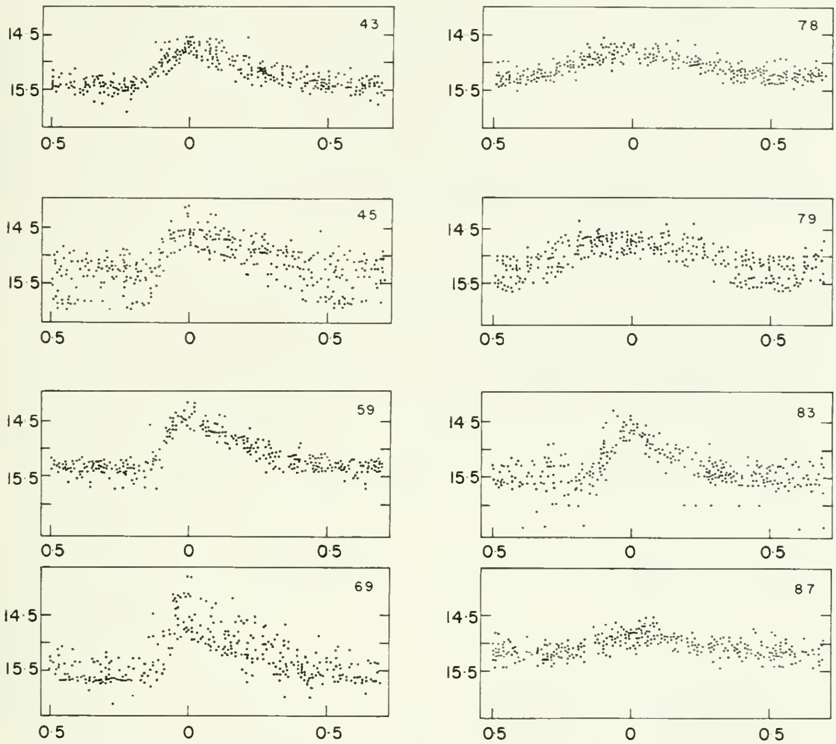

FIG. 9—Light curves for stars with constant periods (continued).

Thus, using the present observations, only for variables with periods < 0.3 days is it possible to detect evolutionary changes in period. Almost all the variables in M5 have periods greater than 0.3 day. However, Sandage's computations have been made on the assumption that stars cross the RR Lyrae gap only once and in the direction of decreasing periods, whereas the periods of the stars in M5 exhibit both increases and decreases.

Theoretical calculations of Faulkner and Iben (1966) indicate that stars do change direction of evolution on the horizontal branch. They have considered models with two different hydrogen compositions in the envelope: $X_e = 0.90$ and $X_e = 0.65$. These models have double energy sources: helium burning in the core and hydrogen burning in a shell outside. In the models with $X_e = 0.90$, the helium burning in the

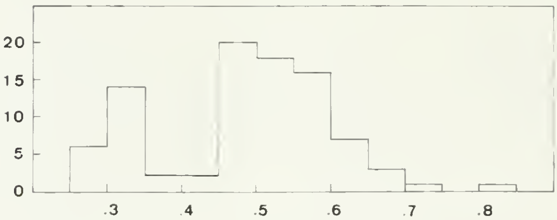

FIG. 10—Period-frequency diagram for M5.

core dominates the energy production and the stars move to the right in the H-R diagram (analogous to stars moving off the main sequence). Then, when the core is exhausted and gravitational contraction sets in, the star moves to the left in the diagram, but much faster. The favoured model with this composition spends about 4×10^7 years crossing the horizontal branch (about 1.3×10^7 years as an RR Lyrae variable) corresponding to an average increase of period at the rate of 0.04(2) days per million years followed by decrease of period at a faster rate. On the other hand, in their models with $X_e = 0.65$, the hydrogen burning in the shell dominates the energy production and there is a resulting contraction in the envelope to maintain a high temperature and density in the shell, causing evolution to the blue in the H-R diagram. When a point is reached where helium burning in the core dominates the energy production, the star evolves to the red at a much faster rate. In the model favoured by Faulkner and Iben (1966) with this hydrogen envelope composition, the star spends 1.3×10^8 years on the horizontal branch evolving to the blue (about 4×10^7 years in the RR Lyrae stage). This would indicate an average decrease of period of 0.014 days per million years followed by an increase at a faster rate. This rate of decrease is below the limit of detection for periods greater than 0.4 days, and most of the decreases are observed at periods greater than this value.

In the case of the models with $X_e = 0.90$, the average increase of periods at the rate of 0.042 days per million years predicted by the theory is approximately what is observed, but the observed decreases are at the same rate, and not faster as expected from the theory.

It therefore seems likely that the observed period changes are not caused by the evolution of the stars across the H-R diagram.

Furthermore, Sandage (1965) has pointed out that if the RR Lyrae stars follow evolutionary tracks like those of Faulkner and Iben (1966),

then there would be a correlation between the rate of period change and the mean magnitude of the RR Lyrae stars. All the stars with decreasing periods would be brighter or fainter than those with increasing periods. An examination of 26 stars in M3, using period changes determined by Szeidl (1965) and mean m_{pg} and m_{pv} colours determined by Roberts and Sandage (1955), does not indicate any correlation between period changes and mean magnitudes, nor does an examination of 14 stars in ω Centauri, with the period changes determined by Belserene (1964) and mean B, V magnitudes of Dickens and Saunders (1965). However, these are very small samples.

An explanation for observed period changes based on evolution also seems difficult because the patterns of observed period changes differ from cluster to cluster. In ω Centauri, there is a predominance of variables with increasing periods, while in M3, there are equal numbers increasing and decreasing, and about half of the stars investigated show irregular period changes. In M15 and M5, a significant proportion of the stars investigated have periods which have remained constant throughout the years of investigation. (Light curves for the variables in M5 with constant periods are shown in figure 9.)

In the case of a variable whose period appears constant, it is possible that the period is changing at a rate too slow to be detected, or that, if the change is abrupt, it has not occurred in the observed time interval. Assuming that the periods of the stars in M5 change abruptly, the period changes so determined are shown plotted against the values of β determined from the assumption that the period varies at a constant rate. With the exception of variable 98 (with an unreliable β), the points define a straight line with a slope slightly greater than unity (about 1.2) which seems to justify the determination of rates of period change by fitting intersecting straight lines to the diagram. This is useful because many of the phase-shift diagrams (that of variable 19 in particular) resemble straight lines more than parabolas.

It is important to determine whether or not the period changes are abrupt, because our interpretation of the observed constancy of period for some of the stars depends on this. To do this, we must accumulate observations for another 30 years and then plot new phase-shift diagrams for the stars which appear to have constant periods at the present time. If they do exhibit period changes, it will not be justified to consider them as variables with constant periods with regard to evolution.

Also we might arrive at the most suitable interpretation of the

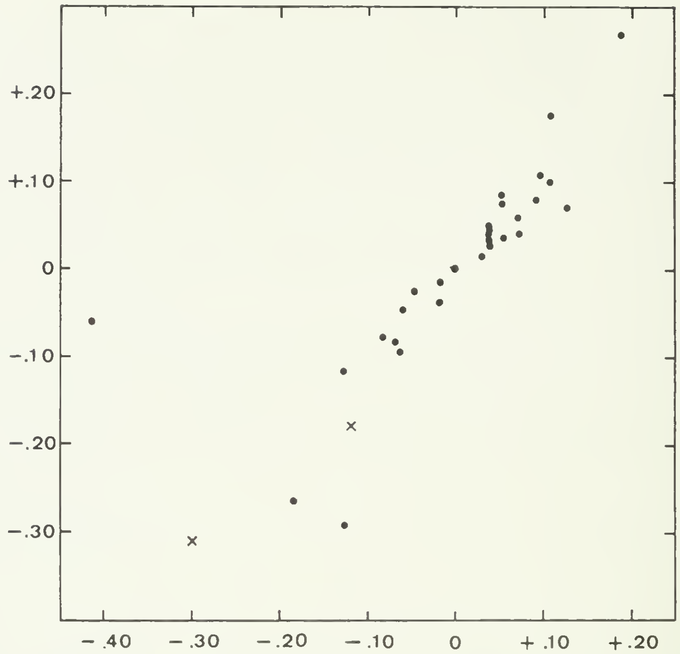

FIG. 11—Projected period changes (days per million years) versus β (in days per million years).

diagrams by reinvestigating the stars with observed period changes. If the diagram is a parabola, then as different periods are tried, the parabola should retain its shape, but the position of the vertex should shift so that it occurs on the time axis at the point where the assumed period is actually the true period. If the diagram is best represented by two intersecting straight lines, then the point of intersection should always occur at the same time, as different periods are tested. The slopes of the lines would change, but the difference in slope should remain constant. This method is now being explored at the Asiago Astrophysical Observatory for some of the stars in M5. Before the possible evolutionary interpretations of the period changes observed in the different clusters can be considered, it is important that the significance of the apparent constancy of period for some of the stars be understood.

A very important point illustrated by this study is the necessity to observe the clusters at least once every two or three years. When there

are ten-year gaps between series of observations, it becomes difficult in many cases, to know how to draw the diagram.

From this investigation, it does not appear that the period changes are caused by the effects of evolution. However, the time is approaching when we might expect to be able to determine such changes.

Acknowledgements

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By Christine M. Coutts* and Helen Sawyer Hogg

Abstract

The purpose of this investigation is to study periods of the variables in NGC 6171 over a long time interval and to look for period changes in the RR Lyrae stars. The study is based on a collection of 47 photographs taken at the David Dunlap Observatory between 1946 and 1969 and 24 photographs at Cerro Tololo in 1970 combined with published observations of other investigators dating back to 1935.

Twenty-three variable stars have been studied. Twenty-two of these are RR Lyrae stars, 10 of which show period changes. One of the variables is a long period variable with a period of 332 days. All the variables inside the cluster radius are RR Lyraes.

Introduction

NGC 6171 (Messier 107, R.A. $16^h29^m.7$, Dec. $-12°57'$, 1950) is a globular cluster with a relatively high metal content. There are 24 variables which Oosterhoff (1938) discovered on fifteen plates taken with the Mt. Wilson 60-inch reflector in 1935. He published magnitudes for 23 of the stars and photometer readings for variable 22, which was much fainter than the others and below his magnitude sequence. His material was not adequate for period determination and the periods for these stars were not found until much later.

Mannino (1961) at Bologna and Kukarkin (1961) at Sternberg both investigated the periods of the variables. Mannino's work was based on 199 photographs taken with the Loiano 60-cm. reflector during 1959 and 1960. He made visual estimates of the apparent magnitudes for 15 of the variables and determined periods for 10. Kukarkin took 67 photographs of the cluster with the 40-cm. reflector at Sternberg, also during 1959 and 1960; he determined periods for 19 of the stars from visual estimates.

Thirty-one variables beyond the visible boundaries of the cluster have been announced. Kurochkin (1962, 1964) found 29, of which 14 are RR Lyrae and Kukarkin (1962) found 2, for one of which he determined an RR Lyrae period.

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The periods of the variables in the cluster given by Kukarkin and by Mannino agree fairly well for all except three, numbers 2, 3, and 8. Mannino considered all of these stars to be RR Lyrae variables of type *c*, while Kukarkin's results definitely show them all to be of type *a*, and in all three cases,

$$\frac{1}{P_K} = \frac{1}{P_M} - 1$$

where P_K, P_M are the periods by Kukarkin and Mannino respectively.

Variables 1, 11, 20, 22, and 24 were not measured by either Kukarkin or Mannino. Variables 1 and 22 were too far from the centre of the cluster to appear on their plates, and variables 11, 20, and 24 were too close to the centre to be resolved.

Since we began work on this cluster, Dickens (1970) has published an extensive paper on it, making use of some of our unpublished data. He studied all the variables except nos. 1, 22, and 24. His work is based on 25 U, 48 B, and 45 V plates of the cluster, all taken with the Mt. Wilson 100-inch telescope in 1966 and 1967.

Investigations at the David Dunlap Observatory

The observing program on NGC 6171 was begun by one of us (Sawyer Hogg) in 1946 with the 74-inch reflector. The David Dunlap Observatory collection includes 46 photographs taken with this telescope in 10 different years between 1946 and 1969 and one photograph (D250) taken with the 16-inch reflector on the campus of the University of Toronto in 1969. This material has been supplemented by 24 plates taken by Coutts with the Curtis 24-inch Schmidt of the University of Michigan on Cerro Tololo in 1970.

Twenty-three stars have been measured on the David Dunlap plates. Variables 6, 7, 8, 9, 11, 20, and 24 were measured visually, the others with an iris photometer. Variable 22, probably not a cluster member, was again too far from the centre of the cluster to appear on the David Dunlap plates and it was not studied. All measures of the variables on the Cerro Tololo plates were made with an iris photometer, but variables 9, 11, and 24 were too crowded for measurement. The photographic magnitudes and heliocentric Julian Days are in Table I. Variable 1 is considered separately later. All the observations up to and including Julian Day 2440393 are from David Dunlap plates; all later observations are from Cerro Tololo.

The adopted periods are listed in Table II, which also gives the photographic magnitudes at maximum and minimum light, the ampli-

TABLE I

Photographic Magnitudes

TABLE I. PHOTOGRAPHIC MAGNITUDES

Dunlap	Julian Day	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11
12068	31970.762					15.65	15.95		16.20		16.05
12116	76.729	15.67	15.92	15.91	15.93	15.70	15.95	15.95	15.80	16.23	16.05
12121	.767	15.84	16.00	15.63	15.98	15.70	16.05	16.00	16.00	16.22	16.05
12140	77.709	16.41	15.54	15.74	16.17	15.70	15.75	15.40	15.85	15.41	15.65
12261	99.720					16.10	16.10	16.00	15.70		15.85
12280	2000.695					15.85	16.10	15.50	15.70		16.25
12326	04.682	15.53	16.09	15.56	15.66	16.25	15.85	15.55	16.25	16.32	16.20
13400	354.693	15.50	16.10		16.03	16.05	16.50	15.95	15.80	16.06	15.70
13426	55.712	16.36	16.09	15.55	16.24	16.00	16.40	15.40	16.05	16.22	16.05
13446	56.674	16.28	15.82	16.06	15.86	15.70	16.45	16.35	16.00	15.38	16.00
13447	.697	16.30	15.75	16.09	15.96	15.75	16.40	16.40	16.30	15.39	16.00
13462	57.675	15.89	15.62	15.52	16.19	16.00	16.40	16.35	16.15	16.23	15.70
14512	733.679	16.38	16.12	15.96	15.85	16.30	16.25	15.60	16.00	16.21	16.00
14517	.722	16.34	15.70	15.68	15.71	16.00	16.20	15.85	16.05	16.29	16.00
14536	34.661	16.22	16.12	15.77	16.08	16.05	16.15	16.35	16.10	16.33	16.05
14542	.732	16.32	16.18	16.15	16.21	16.20	16.30	15.40	16.20	16.43	15.65
20077	4538.691	16.34	15.62	16.04	16.19	15.80	16.25	16.40	16.00	16.08	15.60
20229	72.634	16.02	15.82	15.85	15.93	16.35	16.50	16.30	16.00	16.35	16.05
20241	73.647	15.91	16.26	16.05	16.24	16.20	16.20	15.95	16.05	16.03	15.80
20275	75.612	16.23	15.80	16.11	16.20	15.80	16.30	16.35	16.10	15.67	16.05
21416	930.630							16.45	15.70		15.95
21424	31.636							16.35	15.75		
22472	5307.634	15.94	16.23	15.66	16.22	16.25	16.35	15.50	15.70	16.38	15.85
22475	.673	16.25	16.28	15.67	16.25	16.15	16.45	15.65	15.65	16.52	16.15
26830	8198.715	16.09	16.01	15.76	16.26	15.95	16.25	16.40	16.15	15.41	15.70
26833	.744	16.19	16.06	16.00	16.47	16.10	15.95	16.15	16.25	15.66	15.70
26850	99.679	15.75	15.53	16.22	15.86	15.75	16.05				16.05
26852	.702	15.69	15.84	15.96	15.80	15.75	16.10	15.90	16.10	16.08	
26856	.740	15.73	16.03	15.63	15.93	16.00	16.05	16.00	16.15	16.36	16.10
27541	583.724	16.46	16.24	15.82	16.09	16.00	15.65	15.54	16.10	16.38	16.05
27545	84.638	16.14	15.88	15.88	16.12	15.60	16.00	16.23	15.70	16.36	15.60
27561	87.712	16.18	15.96	15.70	16.30	15.60	15.60	15.73	15.90	15.72	15.70
29101	9265.794	16.00	16.33	16.13	15.95	16.10	16.25	15.95	15.60	16.20	15.95
29105	.837	16.05	16.45	16.18	15.39	16.25	16.25	16.10	15.60	15.27	16.10
29144	70.834	15.70	16.32	15.81	15.58	15.85	16.25	15.85		15.41	16.10
29160	71.738		15.75	16.16	16.12	15.85	15.80	16.15	16.05	15.78	16.05
29166	39271.787	16.40	15.97	15.91	16.14	15.95	16.10	15.45	16.05	15.87	16.15
29171	.834	16.25	15.98	15.87	16.05	16.15	16.05	15.20	15.95	16.20	16.25
29557	357.580		16.13	15.77	16.35	15.65	15.60	15.90	15.65	16.20	15.80
32128	40354.772	15.75	16.02	16.05	16.10	16.05	16.10	15.65	16.20	16.10	
32142	56.807	16.50	15.61	16.02	16.00	16.10	16.00	16.15	15.85	16.20	
D250	82.735	16.05	16.06		15.92	15.70	15.60	15.35		16.22	
32203	89.690	16.05	15.80	15.70	15.95	15.75	15.70	16.15	16.10	16.10	15.80
32206	.733	16.30	16.10	15.98	16.05	15.60	15.60	16.40	16.05	16.31	16.05
32210	.777	16.15	16.11	16.05	16.10	15.75	15.85	16.25	15.95	16.20	16.05
32228	93.703	16.25	15.95	15.95	16.40	15.90	15.55	16.25	15.60	15.65	
32231	.745								15.55	15.95	
C.T.I.O											
6408	691.892	16.54	16.34	16.00	16.15	16.18	15.94	15.50		15.70	
6417	92.681	16.15	15.92	15.96	16.23	15.71	15.88	16.06		15.86	
6428	.889	16.06	16.21	16.12	16.27	15.92	15.96	15.04		15.16	
6438	93.681	16.72	15.98	16.18	16.25	15.67	15.90	15.86		15.25	
6443	.801	16.53	16.10	15.84	16.06	16.00	15.90	15.98		15.82	
6447	.874	15.88	15.98	15.83	16.13	16.43	16.03	15.85		15.93	
6477	94.912	16.69	15.88	15.88	16.40	16.24	15.90	16.09		15.20	
6491	95.878	16.42	16.27	16.21	16.11	15.63	15.86	15.59		15.67	
6650	708.793	16.01	16.23	15.84	16.17	16.00	16.07	15.92		15.84	
6927	45.631	16.53	16.35	16.23	16.20	16.32	15.98	15.55		15.06	
6931	47.669	16.18	16.19	16.02	16.35	16.16	15.92	15.92		15.03	
6945	49.679	16.46	16.27	15.72	16.27	15.76	16.29	16.00		15.83	
7031	801.476	16.45	16.00	16.41	16.23	15.98	15.47	15.69		15.47	
7043	.606	16.64	16.39	15.90	16.43	16.16	15.88	15.61		15.54	
7065	02.586	16.35	16.04	16.19	16.00	16.17	15.80	15.61		15.18	
7077	03.486	16.00	16.39	16.22	16.20	16.30	15.45	15.88		15.37	
7087	.632	16.20	15.90	15.94	16.16	16.06	15.96	15.73		15.59	
7107	05.663	16.47	16.17	16.21	16.25	15.81	16.09	15.72		16.00	
7115	06.493	16.21	15.98	16.12	16.41	16.10	15.59	16.15		15.82	
7119	.560	16.19	16.04	16.35	16.41	16.19	15.92	15.37		15.81	
7145	08.469	16.68	16.17	16.43	16.37	15.53	15.52	15.94		15.80	
7155	.613	15.86	16.20	15.73	16.17	16.00	15.84	15.81		15.86	
7166	09.536	16.35	16.29	15.84	16.19	15.65		15.65		16.10	
7172	.634	16.54	16.15	16.23	15.92	15.78	15.96	15.59		15.24	

No. 12	No. 13	No. 14	No. 15	No. 16	No. 17	No. 18	No. 19	No. 20	No. 21	No. 23	No. 24
		16.10						15.75			15.25
16.18	16.43	16.20	15.63	16.43	16.29	15.75	15.92	15.75	16.29	16.05	15.85
16.23	16.43	16.30	15.80	16.38	16.31	15.74	15.88	15.65	16.28	16.14	15.75
16.40	16.52	16.20	16.12	16.26	16.17	16.31	16.12	15.45	16.66	16.08	15.95
		16.10						16.00			15.95
		16.15						15.30			15.90
16.40	16.20	16.15	15.71	15.60	16.16	16.38	15.89	15.35	16.53	15.90	15.20
16.54	15.67	16.15	16.03	16.26	15.87	16.53	16.10	15.60	16.38	15.88	15.45
16.44	16.20	16.60	16.10	16.52	15.44	16.38	16.28	15.55	16.55	16.04	15.35
16.48	16.30	16.35	16.19	15.97	16.45	16.00	15.81	16.00	16.56	16.23	15.95
16.55	16.52	16.20	16.21	16.12	16.37	16.10	15.76	15.80	16.49	16.24	16.05
16.58	16.56	16.40	15.60	15.82	16.21	15.79	16.25	15.80	16.79	16.17	15.85
	15.30	16.15	15.69	16.12	16.28	16.07	16.12	15.55	16.56	16.08	16.05
16.45	15.75	16.15	15.82	16.25	16.26	16.27	16.36	15.40	16.78	16.22	16.00
16.67	15.60	16.05	16.09	15.89	16.12	16.01	15.88	15.85	16.41	16.11	15.80
15.25	16.32	16.35	16.29	16.13	16.24	15.77	15.92	15.95	16.65	16.28	15.85
15.66	16.57	15.65	16.27	16.35	15.88	16.38	16.18	15.65	16.38	16.19	15.80
16.41	16.58	16.15	15.93	16.29	16.30	16.53	16.01	15.45	16.78	16.18	15.65
15.46	16.50	16.15	16.16	16.33	16.23	16.36	16.20	15.70	16.68	16.13	15.45
15.80	16.72	16.60	16.19	15.88	15.40	16.51	15.90	15.50	16.44	15.83	16.05
		15.45						15.55			15.95
		15.50									
16.30	15.79	16.45	15.85	15.88	16.26	16.57	16.15	15.65	16.49	16.02	15.20
15.65	15.98	16.50	15.89	15.96	16.38	16.07	15.96	15.75	16.46	15.90	15.30
16.09	16.45	16.25	15.83	16.00	16.12	16.39	16.03	15.60	16.38	15.78	15.85
16.40		16.20	15.83	15.95	16.28	16.44	15.82	15.65	16.37	15.70	15.70
		16.50									15.55
16.37	16.56	16.20	16.17	15.78	15.88	16.05	16.38	15.45	16.68	15.65	16.00
16.44	16.55	16.15	16.17	15.90	16.05	16.30	16.28	15.25	16.59	15.84	16.15
16.44	16.33	15.60	15.98	16.48	16.44	16.40	15.97	15.85	16.66	16.39	15.95
16.43	16.14	15.40	16.19	16.22	16.03	16.30	16.14	15.90	16.36	16.35	15.70
15.76	16.26	16.20	15.66	16.07	16.16	16.37	16.26	15.40	16.33	15.86	15.65
16.01	16.15	15.65	16.17	15.97	15.49	16.08	15.83	15.55	16.35	16.04	15.55
15.70	16.40	16.00	15.99	16.17	15.75	16.05	15.49	15.55	16.45	16.11	15.70
16.15	15.85	16.15	15.62	16.42	15.45	15.75	15.74	15.70	16.55	16.15	15.95
16.05	15.95	16.10	15.90	16.40	16.24	16.48	15.94	15.85	16.30	16.20	15.55
16.30	16.23	16.15	16.15	16.46	16.28	16.45	16.38	15.85	16.50	16.30	16.15
16.25	16.41	16.15	16.11	16.53	16.53	16.31	16.39	15.75	16.55	15.95	16.00
15.88	15.62	16.15	16.15	16.50	16.31	16.16	15.80	15.70	16.55	16.05	15.70
16.05	16.10	16.00	15.71	15.96	16.14	16.51	16.15	15.70	16.50	15.95	16.10
		16.15	15.89	16.43	16.02	16.54	16.10	15.75	16.65	15.93	15.70
16.40	16.05	16.10	15.82	16.08	16.17	16.34	16.54	15.55	16.35	16.28	15.30
16.12	15.89	16.25	15.89	16.59	16.19	16.68	16.00	15.45	16.30	15.85	15.90
16.23	16.16	15.55	15.95	16.70	16.05	16.26	16.19	15.65	16.45	16.00	16.10
16.34	16.37	15.20	16.07	16.21	15.43	16.32	16.08	15.70		15.99	16.10
16.05	16.50	15.55	15.82	16.24	15.30	16.30	15.70	15.45	16.60	16.03	15.65
16.07					15.44					16.23	
15.66	16.13	16.22	15.95	16.36	15.79	16.02	16.39	15.15	16.46	16.30	
15.69	15.88	15.24	15.86	15.90	16.18	16.46	16.35	15.38	16.51	16.12	
15.68	16.25	16.22	16.03	16.37	15.52	16.56	16.07	15.30	16.60	16.12	
15.60	16.10	15.32	16.17	16.01	16.09	16.28	16.17	15.10	16.48	15.90	
15.60	16.46	16.20	16.10	16.30	16.24	16.39	16.50	15.15	16.47	16.33	
15.90	16.34	16.32	15.85	16.13	15.93	16.40	16.18	15.34	16.63	16.18	
16.13	15.28	16.40	16.27	16.38	16.26	16.60	16.46	15.20	16.80	16.03	
15.97	15.49	16.30	15.84	16.27	16.11	15.97	16.03	15.38	16.46	16.11	
15.70	16.30	16.15	16.23	15.76	16.05	16.13	16.19	15.20	16.36	16.14	
15.71	16.23	16.32	16.25	16.39	15.59	16.31	16.37	15.18	16.53	16.23	
15.41	15.45	15.69	16.20	16.33	16.20	16.60	16.39	15.24	16.60	16.02	
15.86	16.08	16.14	16.25	16.16	15.96	16.31	15.96	15.18	16.70	16.14	
15.44	15.96	16.23	15.88	16.25	16.08	16.02	16.20	15.20	16.35	16.35	
15.59	16.23	15.67	16.04	16.31	16.12	16.56	16.27	15.40	16.70	16.06	
15.65	16.26	15.71	16.10	16.22	15.96	16.12	16.37	15.13	16.44	16.12	
15.54	16.25	15.24	15.88	16.10	15.71	16.70	16.08	14.94	16.52	16.37	
	16.15	15.86	16.12	16.29	15.88	15.84	16.45	15.14	16.49	15.92	
15.82	16.00	16.15	16.17	16.27	15.55	16.58	16.20	15.22	16.43	16.19	
16.08	15.45	16.16	16.08	16.17	16.15	15.92	16.33	15.06	16.74	15.92	
15.94	15.86	16.29	16.16	15.79	16.22	16.17	16.00	15.26	16.76	15.94	
16.20	16.35	15.96	15.94	16.58	15.76	16.62	16.09	15.32	16.35	16.10	
15.42	16.18	16.17	16.06	15.90	15.94	16.80	16.27	15.28	16.80	16.14	
15.49	15.98	16.15	16.00	16.51	15.45	16.45	16.29	15.13	16.31	16.32	
15.84	16.12	16.02	15.74	16.29	15.88	16.37	16.00	15.12	16.88	16.22	

TABLE II

ELEMENTS OF TWENTY-THREE VARIABLES

Variable	Photographic Magnitudes Max.	Min.	Amp.	Epoch of Max	Period days	β days/10^6yr.
1	14.0	17.0	3.0	40504.	332.	
2	15.6	16.4	0.8	40389.502	0.5710205	
3	15.55	16.25	0.7	40389.595	0.566343	
4	15.5	16.15	0.65	40389.628	0.2821317	
5	15.7	16.25	0.55	40389.709	0.70238	0.9
6	15.7	16.25	0.55	40389.740	0.2602558	
7	15.6	16.55	0.95	40389.696	0.49959	−0.15
8	15.4	16.45	1.05	40389.957	0.559921	−0.25
9	15.95	16.35	0.4	40389.583	0.3206025	0.15?
10	15.4	16.6	1.2	40389.532	0.4155329	1.1
11	15.8	16.45	0.65	40389.611	0.592808	−0.21
12	15.25	16.5	1.25	40389.593	0.472956	2.2 to −1.1
13	15.35	16.6	1.25	40389.596	0.466797	
14	15.4	16.5	1.1	40389.763	0.4816129	0.5
15	15.6	16.25	0.65	40389.687	0.2885895	
16	15.65	16.5	0.85	40389.853	0.5228709	−1.6
17	15.4	16.45	1.05	40389.761	0.561154	
18	15.75	16.5	0.75	40389.898	0.564378	
19	15.75	16.3	0.55	40389.822?	0.2787622	
20	15.65	16.4	0.75	40389.653	0.5781113	
21	16.3	16.6	0.3	40389.704	0.258125	
23	15.5	16.2	0.6	40389.725	0.3233436	
24	15.65	16.45	0.8	40389.615	0.3462153	−0.35?

REMARKS TO TABLE II

Variables for which no β is given here are considered as having constant periods and their light curves are shown in Figure II. Values of β have been determined on the assumption of linear period change, as represented in the phase shift diagrams in Figure I.

V7 Period derived from Kukarkin's alternate period 0.4996. His favoured period 0.3332065 did not fit the David Dunlap observations. Period decrease seems indicated but a constant period is not ruled out.

V9 Period increase seems indicated, but a constant period is not ruled out.

V11 Adopted period derived from that of Dickens (0.59280). The value of β is uncertain. The phase-shift diagram is better represented by an abrupt change of period than by a linear change (i.e. two intersecting straight lines rather than a parabola).

V12 The assumed period indicates both an increase and decrease of period over the 35 year interval. If instead, the phase-shift diagram was constructed with P = 0.472972, a period decrease of 1.6 days per million years would be indicated. The adopted period is that which gives the smaller dispersion of points in the phase-shift diagram over the 35 year interval.

V20 Period derived by us and confirmed by Dickens.

V21 Probably not a cluster member.

V24 Period derived by us, but uncertain because there were no observations by Kukarkin, Mannino or Dickens. An alternate period, P = 0.529586 is possible.

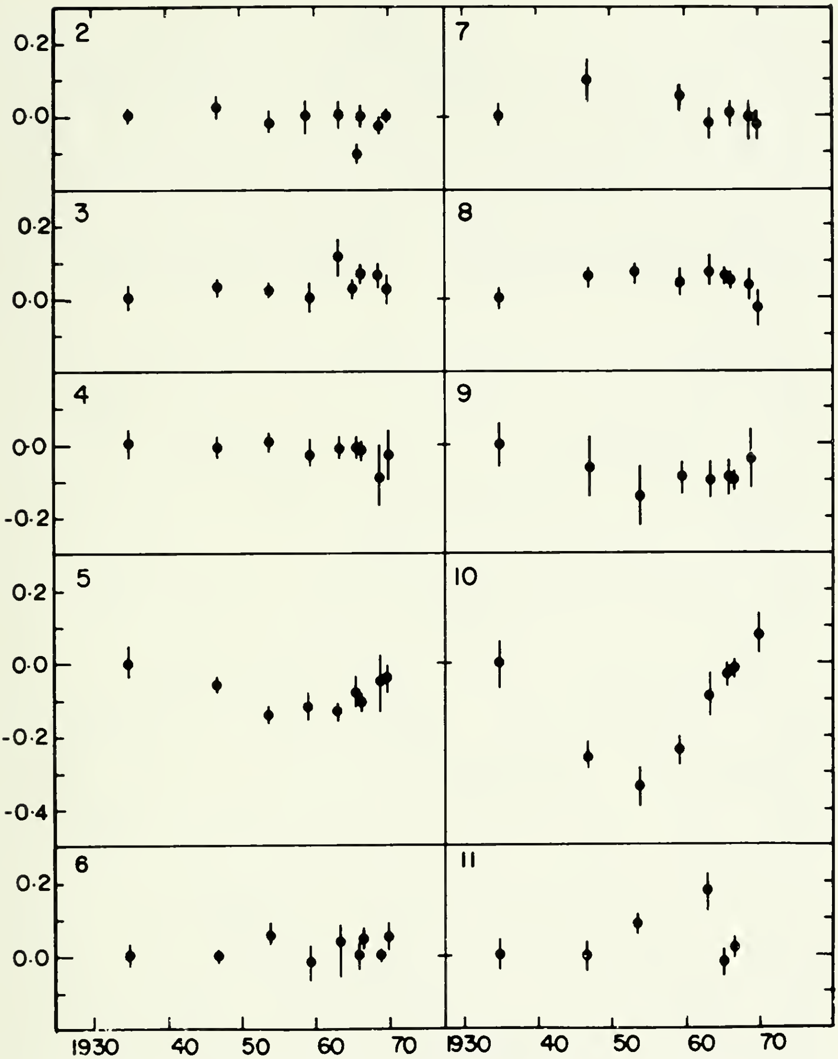

FIG. 1—Phase-shift diagrams (phase-shift vs. year). The marks along the vertical axis are one tenth of a cycle apart. Vertical bars represent probable errors.

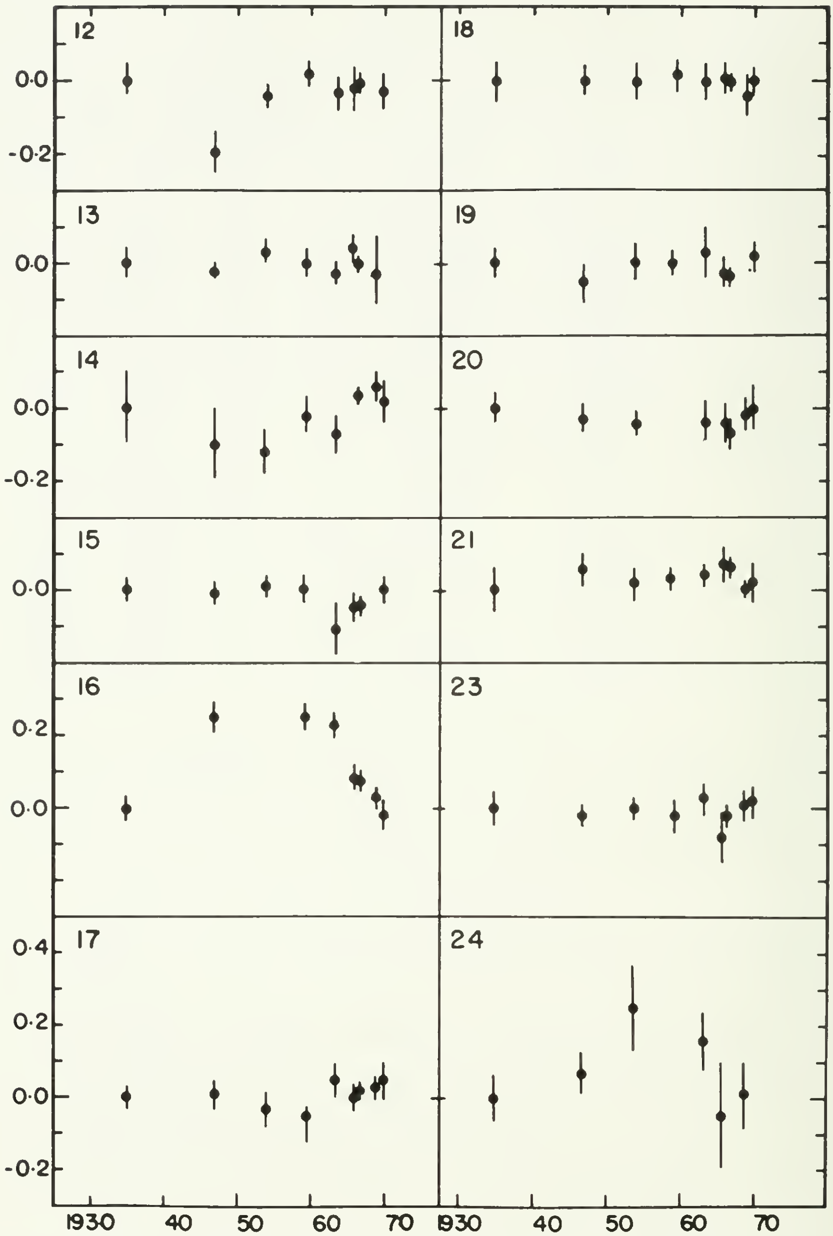

FIG. 1, cont'd—Phase-shift diagrams (phase-shift vs. year). The marks along the vertical axis are one tenth of a cycle apart. Vertical bars represent probable errors.

tudes, the epochs of maximum light and β, the rate of period change in days per million years. The periods were derived from those of Kukarkin (1961) except for variable 7, where we chose his alternate period, and variables 1, 11, 20, and 24. Dickens (1970) has studied variables 11 and 20; he confirmed a value of the period for variable 20 which we communicated to him (Coutts 1964), but ruled out our period for variable 11 so the period we have adopted for this star is based on his value. We are not certain about our value for the period of variable 24 and have suggested an alternative, but it does not fit the observations as well.

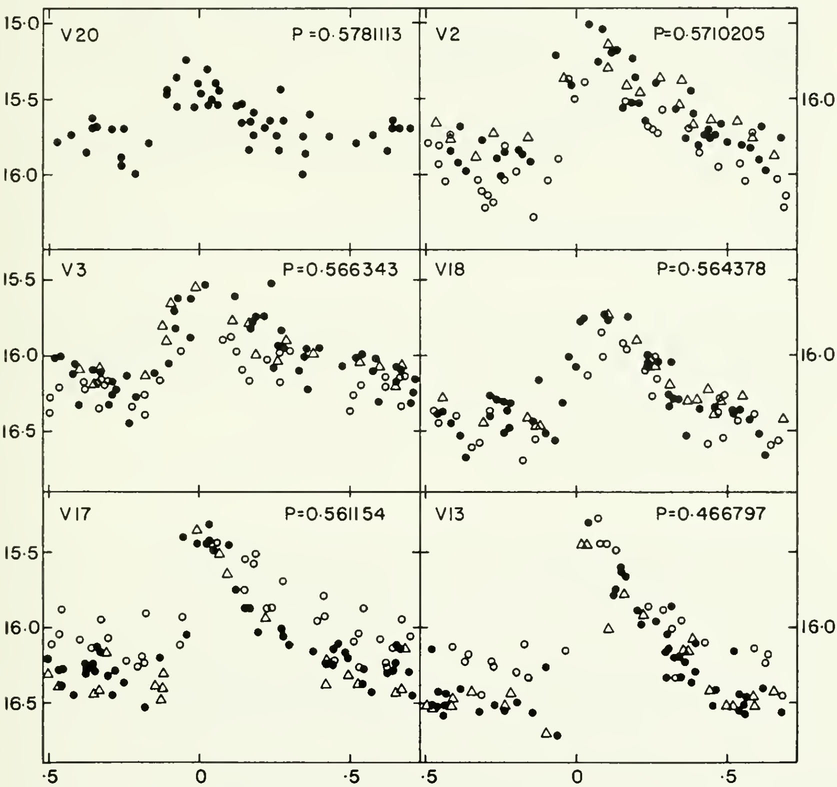

FIG. 2—Light curves for stars with constant periods. The phase is in fractions of a period. Triangles represent the observations from Mt. Wilson (1935), closed circles from the David Dunlap Observatory, and open circles from Cerro Tololo. For variable 20, only the David Dunlap observations are plotted because there are large systematic differences in magnitudes between the observations from different observatories.

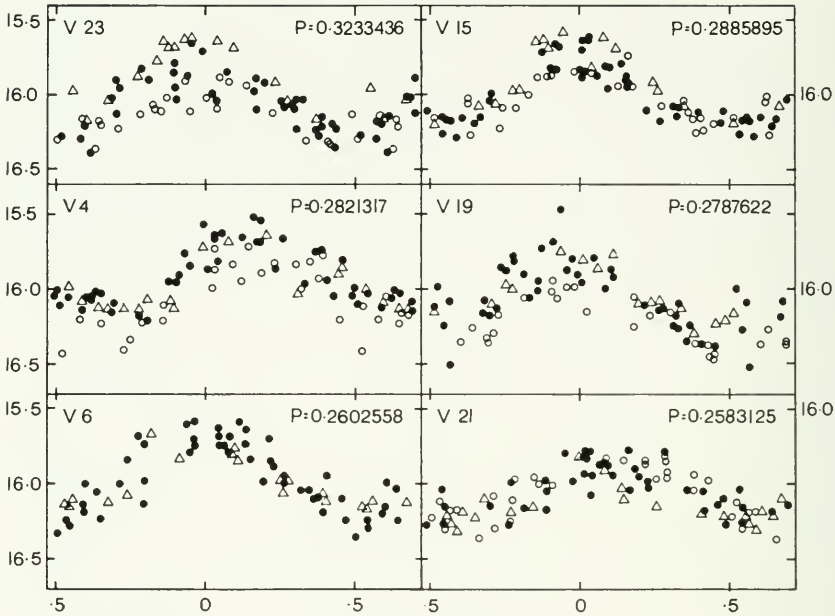

FIG. 2, cont'd—Light curves for stars with constant periods. Triangles represent the observations from Mt. Wilson (1935), closed circles from the David Dunlap Observatory, and open circles from Cerro Tololo. For variable 6, only the Mt. Wilson and David Dunlap observations are plotted because the star is not resolved on the Cerro Tololo plates and the magnitudes are brighter.

We have investigated the variables for period changes by the method described by Belserene (1964). Using the periods of Table II, light curves for the Mt. Wilson 1935 observations were drawn on tracing paper and fitted to the curves for other years to determine the phase shifts. The phase shift data are shown in Table III and the diagrams in figure 1. For twelve of the stars, no period change is indicated over the time interval 1935–1970. Light curves for these stars are shown in figure 2. For the stars which have period changes, β has been calculated as for Messier 5 by Coutts and Sawyer Hogg (1969). Standard parabolas for different values of β/P^2 were fitted visually to the phase shift diagrams and the best value of β calculated. These values of β are listed in Table II and the relationship between β and period is shown in figure 3.

TABLE III

Phase Shifts (in fractions of a period)

Year	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12
1935	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1946–48	.02	.03	−.01	−.06	.00	−.10	.06	−.06	−.26	.00	−.20
1953–55	−.02	.02	.01	−.14	.06		.07	−.14	−.34	.09	−.04
1959–60	.00	.00	−.03	−.12	−.02	.05	.04	−.09	−.24		.02
1963–64	.00	.11	−.01	−.13	.04	−.02	.07	−.10	−.09	.18	−.03
1966	−.10	.02	−.01	−.08	.00		.06	−.09	−.03	−.02	−.02
1966–67	.00	.07	−.02	−.11	.05	.01	.05	−.10	−.02	.02	.00
1969	−.02	.06	−.09	−.05	.00	.00	.03	−.04			
1970	.00	.02	−.03	−.04	.05	−.02	−.03		.08		−.02

Year	No. 13	No. 14	No. 15	No. 16	No. 17	No. 18	No. 19	No. 20	No. 21	No. 23	No. 24
1935	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1946–48	−.02	−.10	−.01	.25	.01	.00	−.05	−.03	.06	−.02	.07
1953–55	.03	−.12	.01		−.03	.00	.00	−.04	.02	.00	.25
1959–60	.00	−.02	.00	.25	−.05	.02	.00		.03	−.02	
1963–64	−.03	−.07	−.13	.23	.05	.00	.03	−.04	.04	.03	.16
1966	.04		−.05	.08	.00	.01	−.03	−.04	.07	−.08	−.05
1966–67	.00	.03	−.04	.07	.02	.00	−.04	−.07	.06	−.02	
1969	−.03	.06		.03	.03	−.04		−.02	.00	.01	.01
1970		.02	.00	−.02	.05	.00	.02	.00	.02	.02	

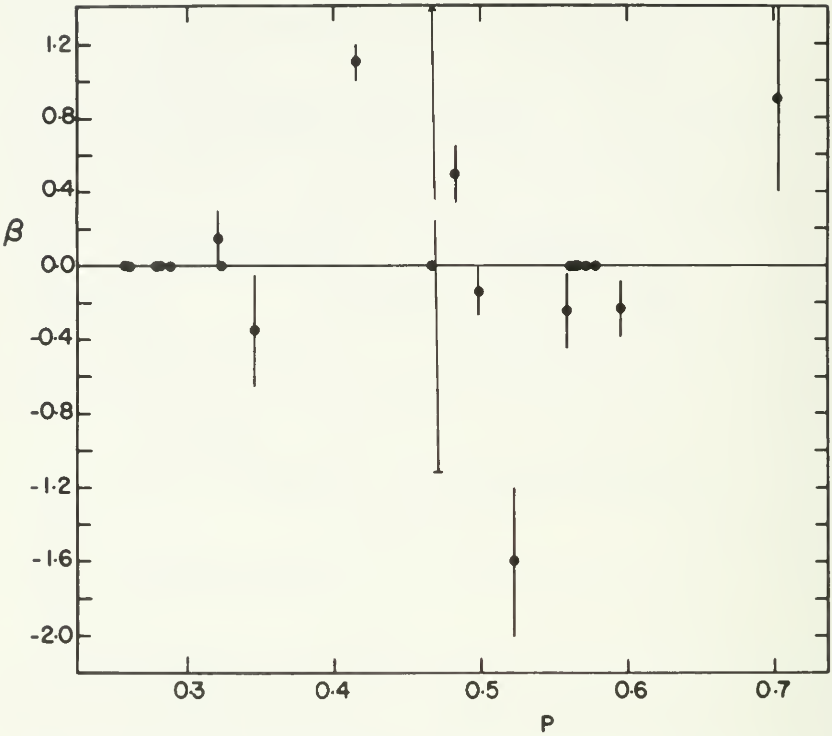

FIG. 3—The rate of change of period β (in days per million years) vs. period (in days). Vertical bars represent the probable errors in β for stars with changing periods.

Variable 1

Variable 1 (V720 Oph) is a long period variable. It is located 8′.9 from the centre of the cluster. The cluster radius is given as 6′.4 by Kron and Mayall (1960). Owing to the distance of this variable from the centre of our plates and the fact that it is brighter than the standard sequence of Oosterhoff at maximum and fainter at minimum it is difficult to determine the magnitudes accurately. In Table IV, we give mean photographic magnitudes and mean Julian Days for all observations separated by less than a week. The period of this variable appears to be very long, 332 days. Its light curve is shown in figure 4. According to Feast (1965), no Mira variables with periods greater than 220 days have been found to be members of globular clusters. He is currently working on the important problem of the membership of this star.

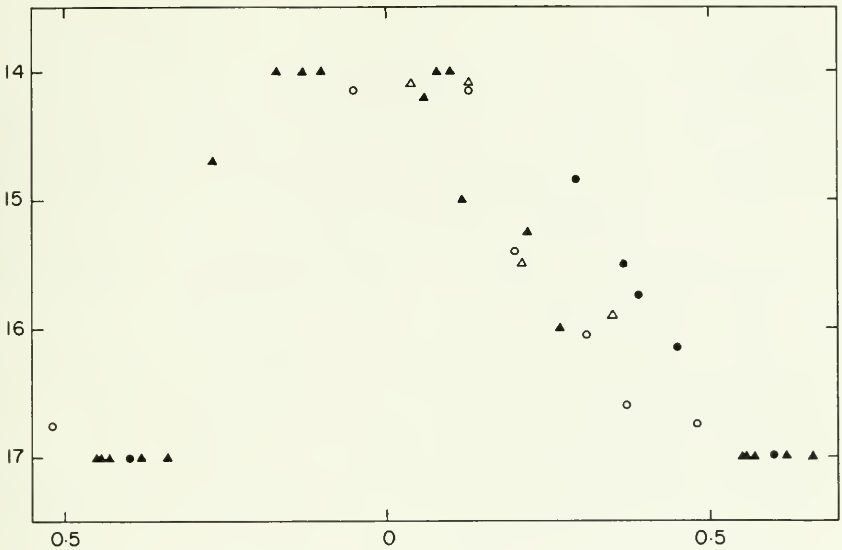

FIG. 4—Light curve for variable 1. The phase is in fractions of a period. Open circles represent the observations of 1935, closed circles 1946–48, open triangles 1953–55 and closed triangles 1963–70.

TABLE IV

MEAN POINTS FOR LIGHT CURVE OF VARIABLE 1

Julian Day	Magnitude
31970	14.85
32000	15.75
32328	15.5
32355	16.15
32734	17.0
34540	14.1
34570	14.1
34930	15.5
35308	15.9
38199	14.2
38585	15.25
39265	16.0
39357	17.0
40355	17.0
40390	17.0
40449	14.0
40692	17.0
40708	17.0
40747	14.7
40801	14.0
40809	14.0
40862	14.0
40870	14.0
40880	15.0

Discussion

There are twenty-two RR Lyrae variables in NGC 6171. Of these, fourteen are of Bailey type *a*, *b* and eight type *c*. One of the type *c* variables, no. 21, is fainter than the others and is probably not a cluster member. Dickens (1970) excludes this variable from his discussion of the properties of RR Lyrae variables in NGC 6171. The number of RR Lyrae type *c* variables is therefore seven. The mean period of the *a*, *b* stars is 0.54 days, and of the type *c* stars 0.29 days. These periods are short for their types, a feature which is characteristic of relatively high metal content. This is expected because the Morgan class of the spectrum is V (Sandage and Katem 1964) and in the colour-magnitude diagram, the horizontal branch is heavily populated on the red side of the RR Lyrae gap (van Agt 1961, Sandage and Katem 1964). The period-amplitude relation is shown in figure 5 and the period-frequency distribution in figure 6. These diagrams indicate that NGC 6171 is a cluster of the Oosterhoff type I, or, as Dickens (1970) notes, it might even represent a somewhat shorter period group.

We have found that almost half of the variables show period changes during the 35 year interval of observations. Four have increasing periods (median rate 0.7 days per million years) and five decreasing (median rate 0.25 days per million years). One variable, no. 12 appears to have had an increase and a decrease in its period over the 35 year interval. Behaviour like this raises doubt that observed changes are caused by evolutionary effects in the stars. Also it can be seen from figure 1 that the observations for both variables 10 and 11 would be better represented by two intersecting straight lines (indicating an abrupt period change) than by a parabola (indicating a uniform change). This problem of the interpretation for phase-shift diagrams was discussed for six stars in M5 by Coutts (1969) who concluded that the hypothesis of abrupt period change was usually better than that of the uniform change.

The period changes for these variables in NGC 6171 are large compared with those in M5 where 20 stars have increasing periods (median 0.05 days per million years) and 12 have decreasing periods (0.075 days per million years). However, we must keep in mind the fact that with observations over a time interval of only 35 years in NGC 6171, the minimum value of β that can be detected when P = 0.5 is 0.15 days per million years.

The period changes of the RR Lyrae variables in M3 are of about the same order of magnitude as those we observe in NGC 6171 and in both clusters there are about the same number increasing as decreasing. On the other hand, almost all the RR Lyrae stars investigated in ω

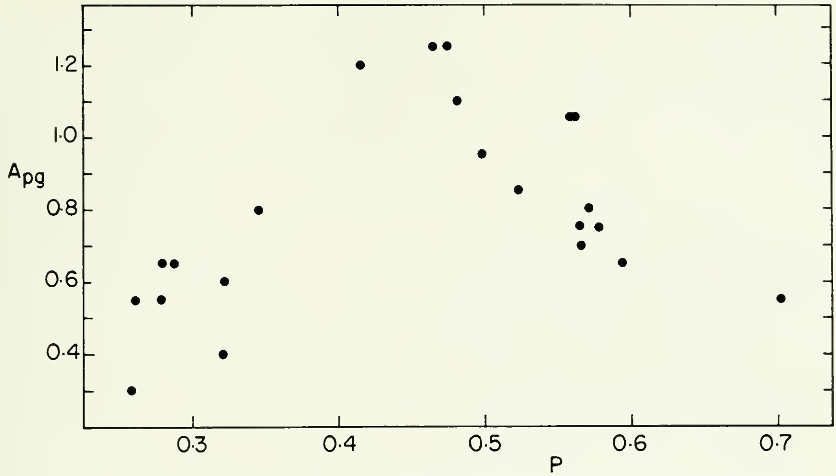

FIG. 5—Period-amplitude relation. The amplitude in photographic magnitudes was calculated from the David Dunlap observations.

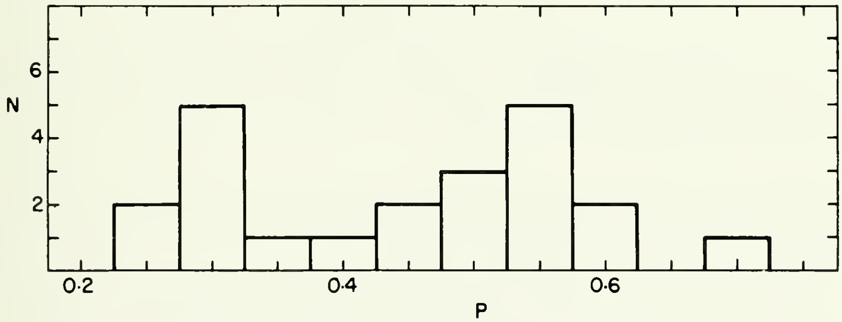

FIG. 6—Period-frequency distribution of the RR Lyrae stars.

Centauri show increases in period. If the observed dispersion in period changes is due to some random noise as Iben and Rood (1970) commented, it would appear that the RR Lyrae periods are increasing at a rate of 0.1 days per million years. These authors pointed out that one of their models for horizontal branch stars ($Y = .30$, $Z = 10^{-4}$) gave a reasonable fit to the observed period changes of the RR Lyrae stars in ω Centauri. They found that a model with $Y = 0.30$, $Z = 10^{-3}$ gave an approximate fit to the observations in M3. It appears that the period changes found for the variables in M5 and NGC 6171 are similar to those in M3 and give a reasonable fit for Iben and Rood's models. However, if the observed increases and decreases are both caused by evolutionary effects, most theories indicate that increases and decreases

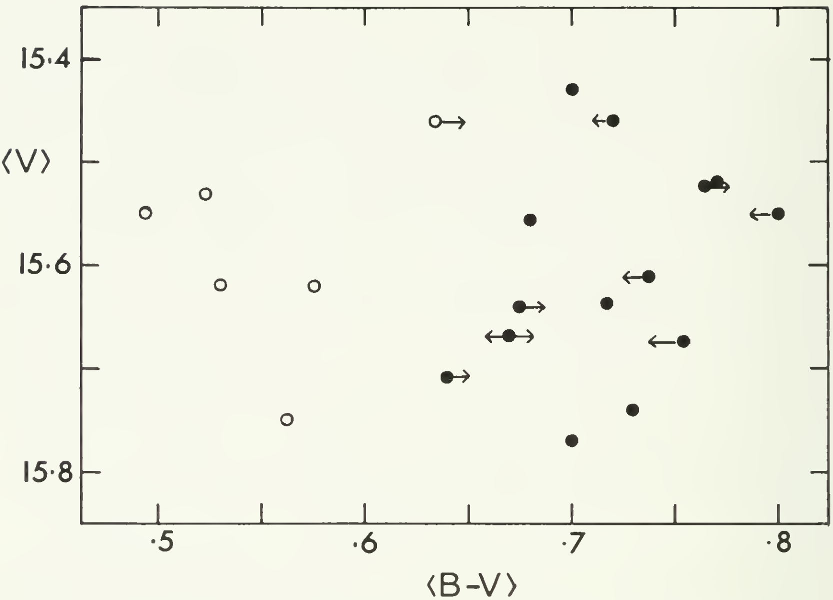

FIG. 7—Colour-magnitude plot of the RR Lyrae variables in NGC 6171. The data are taken from Dickens (1970). Arrows pointing to the right indicate period increases; and those to the left, period decreases.

should be at different rates and consequently we should find more periods changing in the direction in which the evolution is slower. This is not the case in any of these clusters.

Figure 7 shows the positions of the RR Lyrae variables in a colour-magnitude plot. The data have been taken from Dickens (1970). Arrows indicate the direction of the period change (if any). The most noticeable feature of this diagram is the absence of period change among the type *c* variables with $\langle B - V \rangle < 0.60$. It is possible that these stars have constant periods because they are changing the direction of their evolutionary path in the HR diagram.

At the present time, it seems doubtful that the observed period changes are caused by evolution of the stars. It is interesting to note, however, that the period changes indicate a difference between ω Centauri and M3, M5 and NGC 6171. These latter clusters are of the Oosterhoff type I while ω Centauri belongs to the longer period type II group. Belserene (1956) pointed out that ω Centauri appears to be a cluster relatively poor in RR Lyrae variables when their numbers are compared with all the other horizontal branch stars. On the other hand,

according to her investigation M3 and M5 are richer and NGC 6171 is one of the richest clusters. The reality of the separation of the clusters into two groups according to the period changes of their RR Lyrae stars can be better established when the variable rich and metal poor cluster M15 is reinvestigated.

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VARIABLES IN MESSIER 5: A STUDY OF MOUNT WILSON 1917 OBSERVATIONS

By Christine M. Coutts

Abstract

This paper portrays the light curves and gives the epochs of maximum light for 62 variables from Shapley's 1917 collection of photographs of M5. This completes the publication of their magnitudes.

Messier 5 is the fifth globular cluster in richness of variable stars, being surpassed only by Messier 3, Omega Centauri, IC 4499 and Messier 15. Of its 97 variables, 93 are of the RR Lyrae type. The other types represented are W Virginis (nos. 42 and 84), irregular (no. 50) and SS Cygni (no. 101). Periods have been determined for 91 of the RR Lyrae stars (Bailey 1917, Shapley 1927 and Oosterhoff 1941). Period changes have been investigated by Coutts and Sawyer Hogg (1969), and independently by Kukarkin and Kukarkina (1969).

This paper presents the results from the measurement of Shapley's collection of photographs taken with the Mount Wilson 60-inch telescope on eight different nights in 1917. When the periods were published by Shapley in 1927, the individual magnitudes from the plates were not given. For the above-mentioned study of the period changes, Dr. H. W. Babcock, Director of the Hale Observatories, kindly lent us the plates for measurement. The 1917 series on Seed 27 blue-sensitive emulsion consists of 115 exposures on 59 plates. Most of the plates have double exposures with the two images separated by approximately half a millimetre. Previously (Coutts and Sawyer Hogg 1969), measures from 62 exposures on 32 of the plates were published. The present paper, with results from 51 exposures on 26 plates, completes the study. One plate, no. 3753, was not measureable.

Only sixty-two of the 97 variables were measured. The double exposures made measuring difficult in crowded areas and where the resolution was insufficient. Of the 62, 61 are of the RR Lyrae type. The other is the W Virginis star no. 42, with a period of 25.738 days. (The W Virginis, no. 84, was too crowded for measurement.) The stars were measured with a Cuffey iris astrophotometer. The photographic sequence was derived by converting Arp's (1962) B, V sequence to the photographic system. The photographic magnitudes of the 62 variables are listed in Table I with the heliocentric Julian days of the observations. Attempts were made to determine which of the two exposures

TABLE I: PHOTOGRAPHIC MAGNITUDES

Plate	Julian Day	No. 1	No. 2	No. 3	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11
3802	2421424.678	15.26	15.42	15.38			14.71	15.09	15.65	
	.680	15.36	15.42	15.36			14.76	15.07	15.70	15.24
3804	.697	15.69	15.69	15.72	14.84		15.20	15.09	15.76	15.20
	.699	15.69	15.91	15.81			15.26	15.00	15.65	15.72
3805	.716	15.85	15.50	15.85	14.72	15.77	14.97	14.82	15.69	
	.717	15.81	15.85	15.65			15.30	14.78	15.80	
3807	.733	15.50	15.57	15.50	14.96	15.57	15.14	14.67	15.77	15.72
	.735	15.57	15.65	15.45		15.65	15.20	14.59	15.65	15.48
3808	.749	15.42	15.95	15.62	14.76	15.20	15.33	14.57	15.91	15.24
	.750	15.54	15.66	15.50		15.05	15.40	14.62	15.69	15.48
3810	.769	15.54	15.91	15.57		14.45	15.38	14.59	15.70	15.50
	.771		15.91	15.69		14.50	15.42	14.65	15.68	15.72
3811	.785	15.76	15.69	15.69		14.38	15.45	14.74	15.80	15.50
	.787	15.85	15.76	15.69		14.38	15.45	14.76	15.99	15.42
3813	.803	15.81	15.60	15.65		14.55	15.54	14.73	15.80	15.54
	.805	15.65	15.57	15.45		14.53	15.38	14.84	15.72	15.38
3814	.820					14.73	15.48	14.91		
	.821					14.78	15.60	14.91	15.6	15.54
3816	.842									
3817	25.679	15.38	15.72	15.36	14.90	15.85	14.78	15.33	15.73	15.00
	.681	15.33	15.57	15.33		15.77	14.62	15.28	15.75	15.05
3819	.697	15.50	15.50	15.42	15.15	15.79	14.77	15.40		14.95
	.699	15.47	15.45	15.38		15.85	14.71	15.28		15.02
3820	.713	15.60	15.72	15.30	15.07		14.82	15.33	15.73	14.95
	.715	15.54	15.69	15.38		15.89	14.87	15.33	15.85	15.14
3822	.735	15.57	15.65	15.40	15.15	15.38	14.87	15.40	15.88	15.20
	.737	15.85	15.62	15.40		15.33	14.89	15.33	15.85	15.11
3823	.751	15.57	15.65	15.57	15.12	14.73	15.26	15.38	15.85	15.20
	.753	15.57	15.60	15.40	14.98	14.65	14.98	15.33	15.77	15.17
3825	.772	15.76	15.57	15.42	15.09	14.30	15.07	15.36	15.62	15.24
	.774	15.60	15.72	15.40		14.30	15.02	15.42	15.70	15.33
3826	.794	15.69	15.85	15.57	15.05	14.59	15.24	15.42	15.65	15.22
	.796	15.60	15.76	15.45		14.59	15.36	15.45	15.65	15.30
3828	.815	15.60	15.62	15.60	15.09	14.84	15.42	15.62	15.75	
	.818	15.72	15.57	15.50		14.78	15.48	15.57	15.77	15.40
3830	26.705	15.33	15.60	15.12	15.15	15.85	15.65	15.76	15.57	
	.707	15.30	15.45	15.02		15.70	15.57	15.62	15.57	14.73
3832	.721	15.38	15.40	15.02	15.09	15.42	15.42	15.54	15.80	14.24
	.723	15.26	15.45	14.84		15.45	15.22	15.62	15.70	14.26
3833	.758	15.57	15.72	14.82	15.00	14.36	14.67	15.42	15.61	14.34
	.762	15.60	15.62	14.82		14.40	14.73	15.36	15.70	14.51
3835	.777			15.22		14.67	14.67	15.60	15.90	14.65
	.778			15.24			14.86	15.20	15.64	14.80
3836	.793	16.00		15.30		14.88	15.05	15.48		14.67
	.794	15.81		15.14		14.80	15.05	15.17	15.77	14.57
3837	.801	16.00		15.20		14.65	14.95	15.22	15.85	14.80
	.803	16.00		15.22		14.74	14.95	15.11	15.90	14.69
3838	.810	15.76	15.30	15.12	15.28	14.88	14.95	14.82	16.00	14.71
	.812	15.81	15.72	15.05		15.00	14.97	14.84	15.66	14.71
3866	54.721									
	.723									

No. 12	No. 14	No. 15	No. 16	No. 18	No. 19	No. 20	No. 21	No. 25	No. 28	No. 29
14.84	15.20	14.86		14.22	14.62	14.74		14.40		14.95
14.82	15.28	14.84		14.40	14.65	14.82		14.36		15.07
15.12	14.76	15.17	15.30	14.50	14.97	14.69	15.57	14.27		15.09
15.24	14.89	15.05	15.14	14.84	14.97	14.69	15.65	14.35		15.26
	14.38	14.99	15.32	14.78	15.00	14.48	15.65			15.26
	14.40	15.05	15.23	14.73	15.17	14.55	15.54			15.40
15.22	14.57	14.99	15.16	14.67	15.02	14.71	15.57	14.35	15.65	15.50
15.20	14.48	14.91	14.97	14.71	15.00	14.74	15.28	14.27	15.62	15.42
15.40	14.53	15.09	15.18	14.93	15.30	14.76	15.77	14.32		15.26
15.42	14.65	15.09	15.04	14.86	15.30	14.76	15.66	14.25	15.48	15.69
15.36	14.71	15.17	15.30	15.00	15.30	14.95	15.70	14.50	15.07	15.66
15.54	14.80	15.26	15.30	15.09	15.54	15.02	15.80	14.52	15.17	15.69
15.42	14.84	15.42	15.28	15.22	15.44	14.97	15.85	14.44	14.82	15.50
15.38	14.86	15.48	15.32	15.30	15.72	14.89	15.85	14.54	14.82	15.57
15.54	15.02	15.42	15.32		15.54	14.93	15.77	14.44	14.57	15.65
15.44	15.02	15.42	15.28		15.50	14.95	15.69	14.43		15.60
15.47	15.11	15.62	15.44	15.48		15.07	15.57	14.59	14.71	
15.50	15.05	15.65	15.26	15.40		15.05	15.54	14.52	14.69	
15.30	14.67	15.07	14.59	15.07	15.36	15.60	15.42	14.32	15.80	15.57
15.22	14.57	15.02	14.35	14.98	15.30	15.54	15.40	14.27	15.69	15.65
15.28	14.36	14.97	14.14	15.12	15.48	15.38	15.60	14.41	15.70	15.50
15.24	14.32	15.02	14.02	15.02	15.50	15.40	15.50	14.32	15.66	15.50
15.44	14.50	15.05	14.16	15.12	15.62	15.42	15.50	14.39	15.80	15.88
15.38	14.45	15.05	14.04	15.20	15.60	15.54	15.42	14.41	15.69	15.70
15.48	14.65	15.02	14.18	15.33	15.54	15.50	15.48	14.37	15.69	15.72
15.45	14.69	15.14	14.18	15.33	15.69	15.57	15.44	14.41	15.65	15.65
15.54	14.78	15.20	14.20	15.50	15.85	15.57	15.69	14.44	15.75	15.77
15.50	14.71	15.14	14.18	15.44	15.76	15.45	15.57	14.35	15.63	15.73
15.64	14.86	15.24	14.38	15.57	15.76	15.72	15.81	14.41	15.75	15.77
15.70	15.00	15.20	14.30	15.57	15.85	15.76	15.57	14.43	15.70	15.80
15.80	14.91	15.38		15.65	15.72	15.69	15.69	14.46	15.75	15.95
15.67	15.00	15.40	14.36	15.57	15.85	15.88	15.69	14.50	15.64	15.77
15.80	15.20	15.65	14.49	16.00	15.88	15.62	15.66	14.52		15.71
15.70	15.17	15.54	14.52	16.00	15.85	15.69	15.70	14.48		15.69
15.62	14.67	15.05	15.26	15.65	15.62	15.20	14.55	14.35	15.69	15.73
15.60	14.73	15.00	15.26	15.40	15.57	15.17	14.53	14.32	15.54	15.71
15.57	14.67	15.07	15.38	15.88	15.88	15.26	14.59	14.39	15.80	15.69
15.66	14.57	15.05	15.2	15.62	15.72	15.17	14.57	14.37	15.66	15.71
15.73	14.89	15.14	15.35	15.91	15.72	15.38	14.84	14.41	15.72	15.72
15.85	15.00	15.14	15.28	15.95	15.65	15.24	14.84	14.39	15.57	15.60
16.00	14.91	15.44		16.00		15.26	15.14	14.67		
15.68	15.02	15.62		16.00	15.81	15.14	15.07	14.61		
15.69	15.14			16.00			15.57	14.65		
15.40	14.91	15.33		16.00	16.0		15.20	14.50		
	15.36	15.65		16.00	15.95		15.40	14.44		
	15.14	15.45		16.00	16.04		15.28	14.32		
16.00	15.17	15.54		16.00	15.91	15.42	15.12	14.56		15.3
16.00	15.24	15.50		16.00	16.08	15.48	15.12	14.54		15.17

Julian Day	No. 30	No. 31	No. 32	No. 33	No. 35	No. 38	No. 39	No. 40	No. 41	No. 42
2421424.678			14.84	14.82		15.22		15.12	15.36	12.10
.680			14.86	14.84		15.36		15.00	15.36	
.697	15.48	15.62	14.65	14.91	15.20		15.36	15.09	15.26	
.699	15.50	15.57	14.59	14.89	15.40		15.57	15.11	15.26	
.716	15.44	15.48	14.05	15.00	15.28		15.60	14.95	15.30	
.717	15.57	15.42	14.26	15.20	15.40		15.48	15.02	15.40	
.733	15.42	15.40	14.28	15.26	15.13		15.44	14.89	15.48	12.20
.735	15.24	15.26	14.30	15.07	15.08		15.40	14.73	15.48	
.749	15.50	15.40	14.53	15.22	15.06		15.57	14.78	15.48	12.10
.750	15.42	15.42	14.53	15.20	15.00	15.65	15.54	14.82	15.38	
.769	15.54	15.42	14.69	15.36		15.62	15.81	14.95	15.72	11.95
.771	15.62	15.48	14.80	15.33	15.13		15.81	14.91	15.65	
.785	15.57	15.30	14.86	15.40		15.45	15.75	14.93	15.70	11.75
.787	15.57	15.40	14.95	15.36	15.18	15.65	15.80	14.97	15.70	
.803	15.50	15.02	15.07	15.44	14.82		15.72	14.97	15.81	11.85
.805	15.47	15.02	14.97	15.42	14.82	15.54	15.65	14.93	15.62	
.820	15.72	15.07	15.22					15.18		11.75
.821	15.60	14.91	15.38		14.71			15.12		
.842										12.15
25.679	15.14	15.48	14.67	14.88			15.36	14.91	15.30	
.681	14.95	15.42	14.78	14.91	15.19	15.70	15.28	14.97	15.42	
.697	14.91	15.22	14.89	14.93	15.06		15.40	14.84	15.57	12.15
.699	14.74	15.12	14.78	15.00	15.10		15.30	14.95	15.57	
.713	14.82	14.97	15.00	14.95	15.00	15.60	15.42	14.84	15.42	12.05
.715	14.76	14.89	14.97	15.02	15.02	15.67	15.44	14.93	15.40	
.735	14.86	14.93	15.09	15.17	14.87	15.54	15.44	14.82	15.62	12.15
.737	14.84	14.95	15.20	15.12	14.71		15.54	14.89	15.69	
.751	15.00	14.91	15.38	15.26	14.64	15.62	15.62	14.86	15.72	12.05
.753	14.95	14.95	15.26	15.07	14.56	15.62	15.50	14.95	15.60	
.772	15.02	14.88	15.42	15.33		15.60	15.54	14.95	15.72	12.20
.774	15.00	14.88	15.42	15.17	14.68	15.62	15.54	14.93	15.72	
.794	15.17	15.00	15.57	15.12	14.58	15.48	15.62	15.09	15.60	12.00
.796	15.12	14.97	15.48	15.24	14.58	15.48	15.62	15.07	15.69	
.815	15.26	15.12	15.72	15.40	14.60	15.60	15.76	15.24	15.75	11.85
.818	15.26	15.14	15.69	15.44	14.64	15.70	15.62	15.26	15.66	
26.705	15.72	14.95	15.44	15.00	14.75	15.65	14.57	14.89	15.50	12.00
.707	15.57	15.00	15.44	14.91	14.56	15.60	14.53	14.93	15.50	
.721	15.75	15.17	15.69	15.17	14.68	15.60	14.67	15.02	15.65	12.25
.723	15.63	15.14	15.48	14.91	14.57	15.30	14.55	15.00	15.62	
.758	15.65	15.30	15.69	15.24	14.73	15.62	14.89	15.14	15.81	12.05
.762	15.65	15.26	15.81	15.22	14.68		14.89	15.24	15.50	
.777	15.65		15.85				14.80			12.15
.778	15.75	15.57	16.00		14.94		14.86			
.793	15.75					14.73	14.82		16.00	12.35
.794	15.57	15.65	15.85		15.00	14.59	14.69	15.42	15.69	
.801	15.73	15.65	16.00		14.97	14.76		15.50	15.68	12.20
.803	15.63		15.96		14.91	14.67		15.52	15.75	
.810		15.85				14.26	15.09	15.62	15.78	12.00
.812		15.69		15.48	15.08	14.20	15.26	15.50	15.66	
54.721										12.20
.723										

No.43	No.44	No.45	No.47	No.52	No.55	No.58	No.59	No.61	No.62′	No.63
15.22	14.65		15.00	14.55		14.86	15.05	15.38		15.17
15.12	14.76		15.07	14.80		14.84	15.07	15.36		15.20
14.76	14.89	15.72		15.09			14.93	15.70	15.62	15.62
14.95	14.89	15.60		15.40	14.97	14.59	15.07	15.77	15.70	15.54
14.84	15.02	15.70		15.14	15.00	14.55	14.53	15.73	15.26	15.57
14.97	15.05	15.95		15.30	15.02	14.89	14.50	15.85	15.38	15.65
15.05	15.22	15.70		15.24	15.12	15.24	14.59	15.65	15.14	15.40
15.07	15.20	15.73	15.38	15.30	14.91	15.22	14.56	15.65	15.00	15.36
15.05	15.17	15.65	15.50	15.38	14.86	15.28	14.50	15.75	15.02	15.68
14.93	15.12	15.57	15.57	15.28	14.95	15.57	14.84	15.67	14.91	15.75
15.09	15.22	15.60	15.54	15.42		15.72	14.80	15.80	14.91	15.65
15.17	15.14	15.65	15.48	15.44	15.05	15.69	14.91	15.75	15.05	15.70
15.17	15.20	15.36		15.44		15.62	14.74	15.69	14.91	15.75
15.12	15.17	15.33	15.57	15.37	15.24	15.65	14.84	15.72	14.88	15.85
15.26	15.50	14.76	15.42	15.40			14.89	15.65	14.88	15.70
15.22	15.17	14.93	15.42	15.50	15.22	15.69	14.95	15.57	14.86	15.68
15.26	15.22	14.78					15.02	15.72	15.05	15.73
15.26	15.22	14.78			15.38		15.00	15.50	15.00	15.66
15.60	14.82	15.22	15.28	15.14		15.02	15.48	15.05	15.07	15.50
15.60	14.80	15.24	15.14	15.16	15.02	15.00	15.54	15.09	15.14	15.62
15.57	14.80	15.22	15.30	15.22		14.86	15.57	14.93	15.20	15.75
15.50	14.78	15.30	15.17	15.38	14.89	14.93	15.50	14.97	15.17	15.65
15.54	14.91	15.17	15.26	15.24	14.93	15.28	15.72	15.14	15.26	15.68
15.57	14.82	15.24	15.22	15.33	15.02	15.22	15.76	15.17	15.30	15.73
15.69	14.95	15.33	15.33	15.30		15.28	15.65	15.20	15.33	15.62
15.57	14.89	15.24	15.28	15.50	14.95	15.28	15.60	15.14	15.44	15.77
15.54	14.95	15.22	15.40	15.38	15.17	15.42	15.48	15.30	15.60	15.68
15.36	14.97	15.24	15.36	15.42	15.09	15.42	15.42	15.22	15.57	15.66
15.54	15.30	15.40	15.48	15.44		15.54	14.84	15.28	15.67	15.65
15.62	15.12	15.33	15.48	15.50	15.05	15.62	14.88	15.36	15.69	15.70
15.44	15.14	15.20	15.40	15.44	15.20	15.76	14.53	15.48	15.70	15.65
15.42	15.12	15.24	15.36	15.62	15.14	15.85	14.42	15.42	15.70	15.75
15.72	15.22	15.30	15.54	15.55		15.69	14.42	15.54	15.60	15.77
15.60	15.22	15.28	15.38	15.55	15.46	15.69	14.48	15.42	15.54	15.80
15.02	14.80	14.38	14.93	15.20	15.12	15.38	15.57	15.20	15.20	15.57
15.00	14.80	14.53	14.89	15.26	14.95	15.24	15.50	15.14	15.12	15.57
15.00	14.89	14.50	15.02	15.36	15.02	15.42	15.57	14.65	15.00	15.66
15.00	14.91	14.42	15.00	15.34	15.00	15.33	15.57	14.62	15.00	15.68
15.14	15.17	14.65		15.38		15.50	15.50	14.73	14.86	15.73
15.17	15.12	14.71	15.22	15.60	15.14	15.42	15.48	14.78	14.86	15.70
15.07							15.65	15.00		16.00
15.14					15.42		15.48	14.71	14.97	15.85
15.17							15.50	14.65	15.26	16.00
15.00	15.42		15.40		15.36		15.40	14.57	15.09	15.90
15.20	15.57						15.22	14.53	15.22	15.90
15.20	15.57				15.42		15.22	14.57	15.24	15.85
15.09	15.65	15.09				15.69	15.90	14.91	15.26	15.90
15.12	15.50	14.95			15.65	15.88	15.77	15.02	15.22	15.90

Julian Day	No. 64	No. 65	No. 66	No. 67	No. 68	No. 69	No. 70	No. 71	No. 72	No. 73
2421424.678				14.40		16.00	15.30		14.24	15.23
.680				14.40			15.36		14.36	15.23
.697	15.72	15.67		14.38			14.71	15.66	14.30	
.699	15.72	15.70		14.35			14.86	15.90	14.30	
.716	15.72	15.85	15.26	14.30	14.59		15.17	15.70	14.30	14.80
.717	15.60	15.88	15.50	14.38	14.93		15.36	15.90	14.30	14.97
.733	15.57	15.75	15.48	14.86	15.17		15.36	15.75	14.32	15.22
.735	15.50	15.48	15.33	15.02	15.17		15.60	15.60	14.57	15.14
.749	15.76	15.95	15.69	15.07	15.85		15.76	15.95	14.59	15.30
.750	15.48	15.60	15.50	15.00	15.48		15.54	15.77	14.67	15.28
.769	15.67	15.86	15.42	15.17			15.48		14.91	15.33
.771	15.73	15.80	15.65	15.30			15.69		15.07	15.45
.785	15.75	15.65	15.70	15.38			15.87	16.00	15.36	15.72
.787	15.73	15.62	15.70	15.40			15.73		15.36	15.60
.803	15.67	15.60	15.54	15.38			15.87		15.54	15.72
.805	15.48	15.57	15.65	15.28			15.65		15.38	15.60
.820										
.821										
.842										
25.679	15.50		15.22		15.17	15.90			16.00	14.59
.681	15.38	15.65	15.20		15.24	15.90	15.28	15.85	15.95	14.84
.697	15.50	15.69	15.30	14.73	15.42		15.36			14.95
.699	15.40	15.57	15.30	14.78	15.48		15.30			14.97
.713	15.68	15.69	15.22	14.84	15.50		14.73	16.00		15.02
.715	15.65	15.78	15.20	14.80	15.42		14.78	16.00		15.02
.735	15.76	15.73	15.33	14.53	15.48		14.74			14.93
.737	15.62	15.36	15.36	14.65	15.42		14.74			15.07
.751	15.73	15.88	15.50	14.73	15.80		15.00			15.20
.753	15.65	15.69	15.48	14.67	15.75		14.78			14.88
.772	15.75	15.70	15.48	14.84	15.73		15.12			15.24
.774	15.75	15.62	15.44	14.82	15.67		15.05			15.36
.794	15.70	15.89	15.44	15.07	15.85		15.26		15.20	15.42
.796	15.64	15.65	15.54	15.14	15.80		15.24		15.07	15.42
.815	15.77	15.75	15.63	15.12			15.42		14.36	15.60
.818	15.77	15.60	15.70	15.00			15.36		14.38	15.48
26.705	15.28	15.77	14.91	15.54			16.00	15.95	16.00	14.84
.707	15.20	15.50	14.89	15.44			15.90	15.77	15.95	14.84
.721	15.26	15.75	15.14	15.38			15.90			15.00
.723	15.17	15.65	15.12	15.28			15.98			15.05
.758	15.42	15.73	15.12	14.69	15.50		15.95	16.00	15.92	14.97
.762	15.28	15.48	15.17	14.59	15.48		15.95	16.00	16.00	15.02
.777	15.22	15.85	14.91	14.30						14.86
.778	15.38	15.57	15.30	14.30						14.82
.793	15.44	15.20		14.36						15.48
.794	15.24	14.84	15.50	14.32			15.57			15.30
.801		14.76	15.60	14.30			15.48			15.36
.803		14.76	15.64	14.30			15.64			15.30
.810	15.68	14.89	15.57	14.48			15.33			15.24
.812	15.50	14.74	15.62	14.65			15.20			15.30

No.74	No.75	No.76	No.77	No.78	No.79	No.80	No.81	No.83	No.87	No.92
			14.73	15.20	14.89	14.78	14.57			
			14.74	15.38	14.89	15.20	14.46			
13.90	14.71	14.50	14.89	15.24		14.91	15.12		15.02	
13.90	14.89	14.67	15.07	15.36		15.33	14.76	15.85	15.26	14.54
13.90	14.69	14.67	14.93	15.09	15.38	14.88	14.93	15.77	14.91	14.70
13.90	14.89	14.57	14.93	15.24	15.38	15.50	14.78	15.75	15.17	14.77
13.90	15.00	14.71	14.91	15.00	15.07	15.00	15.02	15.77	14.93	14.42
13.90	14.89	14.78	14.91	15.05		15.20	14.73	15.77	14.95	14.44
13.90	15.24	14.76	15.07	14.84	15.22	14.71	15.00	15.72	14.89	14.09
13.92	15.17	14.74	15.00	14.97	15.09	15.07	14.80	15.36	14.93	14.57
13.91	15.26	14.82	14.97	14.82	15.14	14.74	15.17	15.64	14.91	14.72
13.98	15.30	14.95	15.09	15.05	15.22	15.02	15.09	15.62	15.05	14.72
14.18	15.36	14.93	15.09	14.97	15.00	14.84	15.17	15.60	15.02	14.40
14.24	15.28	15.05	15.09	14.95		15.05	15.17	15.60	15.07	14.38
14.10	15.30	15.05	15.02	15.12	14.95	14.76	15.24	15.64	14.91	14.38
14.30	15.28	14.95	15.07	15.00	14.84	14.91	15.09	15.46	15.02	14.07
14.36	15.38	15.09	15.17	15.12	15.00		15.26		15.02	14.22
14.32		15.20	15.09	15.14	14.93		15.30	15.50	15.09	14.57
14.02	15.57	15.09	15.09	15.30	15.24	15.07	15.75	15.40	15.17	14.48
13.96	15.65	15.02	15.24	15.33	15.12	15.36	15.55	15.36	15.26	14.30
14.16	15.69	14.89	15.14	15.44	15.36	15.02	15.85	15.48	15.17	14.26
14.18	15.57	15.02	15.17	15.48	15.22	15.36	15.60	15.50	15.28	14.07
13.98	15.81	15.22	15.20	15.38	15.36	14.82	15.73	15.57	15.17	14.65
14.14	15.76	15.30	15.22	15.38	15.40	15.26	15.54	15.60	15.22	14.42
14.04	15.60	15.26	15.12	15.36	15.33	14.91	15.07	15.50	15.14	14.76
14.00	15.62	15.24	15.24	15.42	15.17	15.20	14.95	15.57	15.26	14.40
14.16	15.76	15.30	15.20	15.33	15.24	14.78	14.95	15.50	15.22	14.22
14.08	15.81	15.24	15.22	15.26	15.26	14.97	14.74	15.57	15.20	14.12
14.12	15.73	15.30	15.17	15.17	14.97	14.67	14.48	15.60	15.24	14.40
14.18	15.80	15.36	15.12	15.07	14.97	14.97	14.38	15.48	15.24	14.38
14.20	15.77	15.40	15.28	14.89	14.89	14.65	14.57	15.50	15.30	14.00
14.24	15.73	15.38	15.30	14.95	15.00	14.88	14.65	15.57	15.36	14.02
14.30	15.73	15.57	15.40	14.93	14.93	14.74	14.78	15.54	15.38	13.50
14.28	15.77	15.48	15.33	14.97	14.91	14.84	14.74	15.44	15.60	13.34
14.28	15.02	15.24	15.28	15.20	15.28		15.72	15.02	15.38	14.07
14.12	14.95	15.20	15.36	15.22	15.20	15.28	15.42	15.14	15.40	14.17
14.16	15.12	15.36	15.26	15.26	15.30	14.97	15.70	15.20	15.36	14.00
14.26	15.07	15.24	15.26	15.44	15.17	15.38	15.48	15.24	15.38	13.97
14.24	15.07	15.00	15.38	15.40	15.07	14.89	15.60	15.36	15.24	13.18
14.18	15.02	14.91	15.36	15.40	15.17	15.14	15.65	15.28	15.12	13.34
14.26	15.26		15.44	15.80	15.44			15.77		13.62
14.26	15.14		15.26	15.65	15.20		15.72	15.73		13.26
	15.20	15.09		15.68	15.07	15.00		15.69		13.73
	15.07	14.95		15.68	14.74	15.14		15.60		13.60
	15.20	14.95		15.67	14.76			15.60		13.91
	15.14	15.05		15.80	14.80					13.70
14.18	15.40	14.97	15.48	15.50	15.02	14.82		15.92		14.02
14.22	15.44	14.97	15.50	15.48	15.02	14.97		15.76		13.93

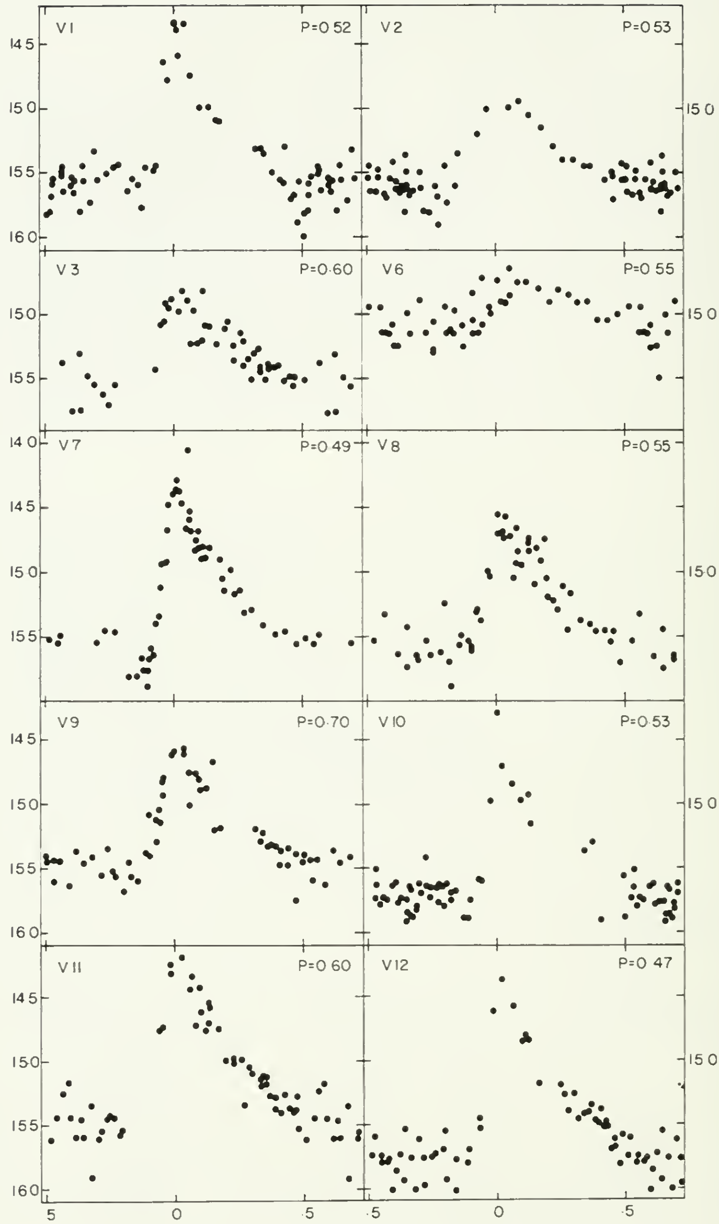

FIG. 1—Light Curves of the 62 Variables.

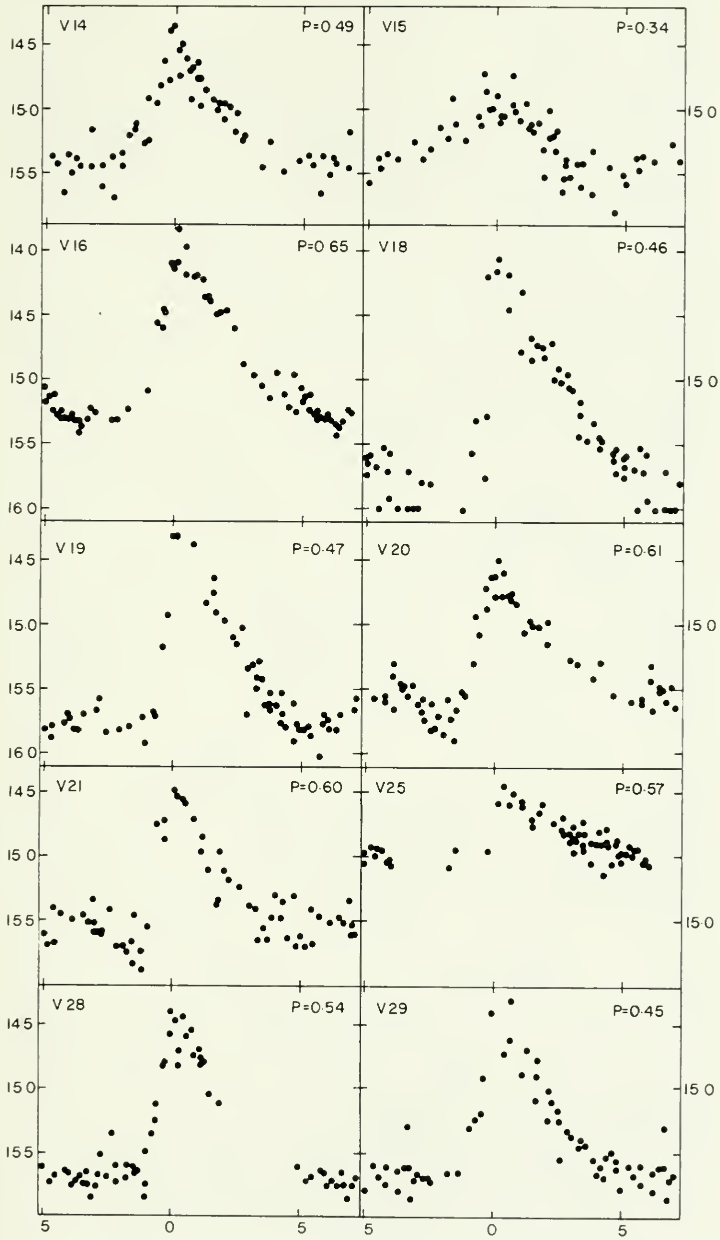

FIG. 1, cont'd—Light Curves of the 62 Variables.

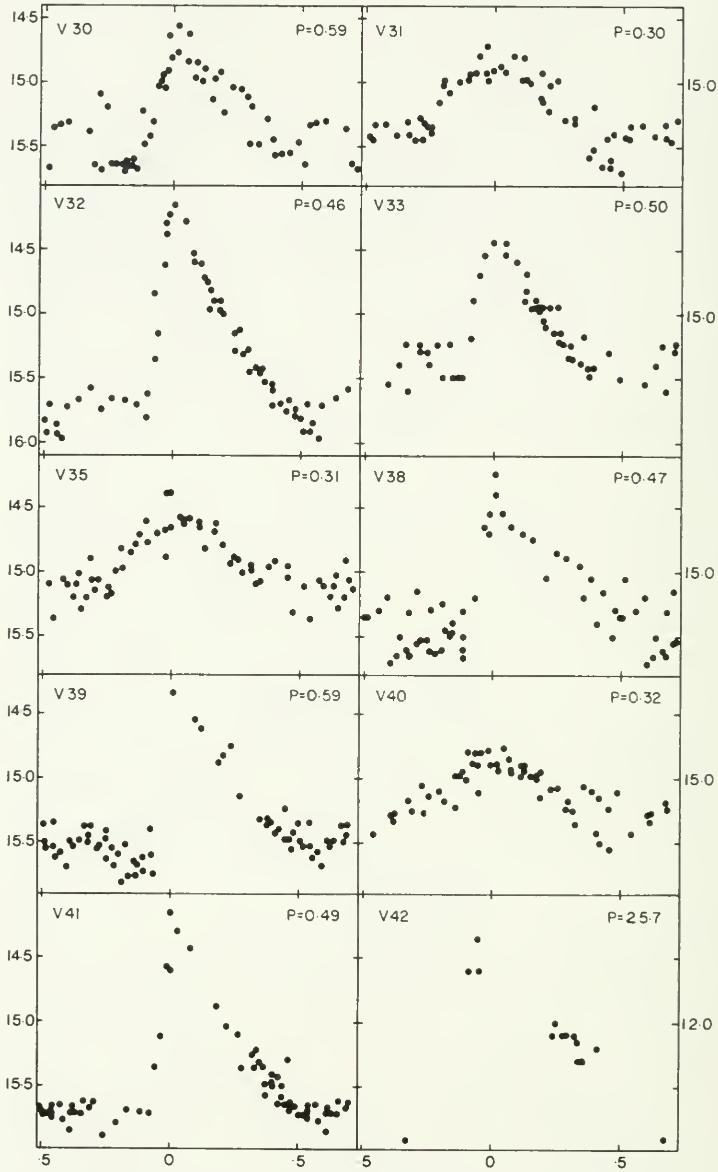

FIG. 1, cont'd—Light Curves of the 62 Variables.

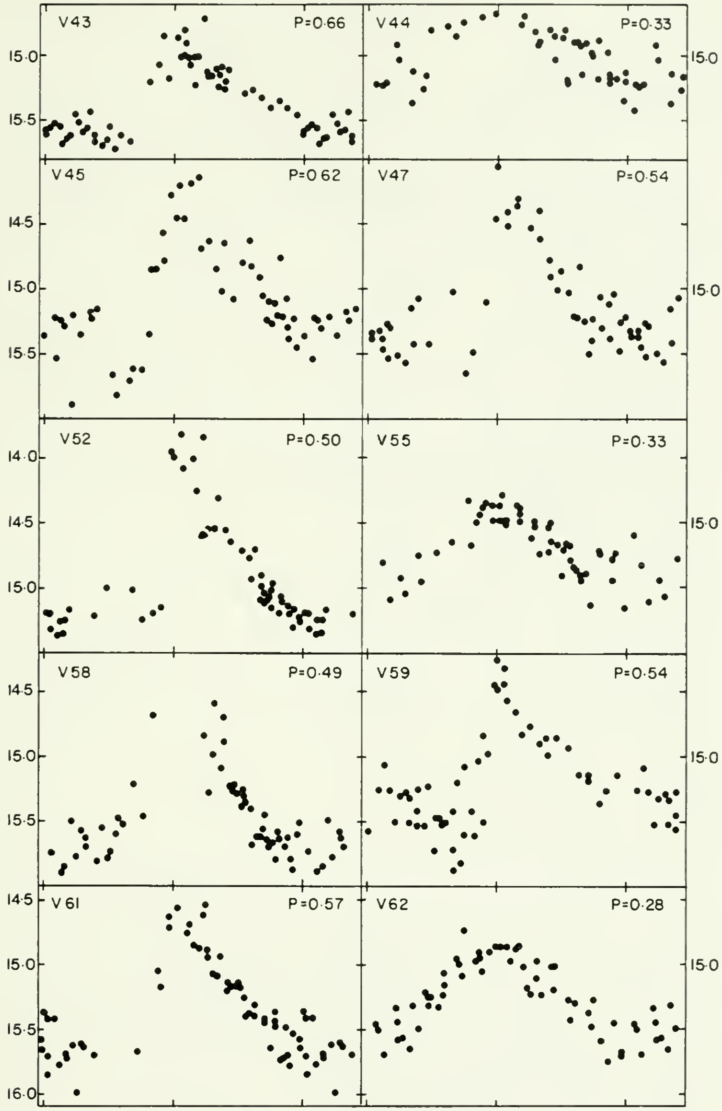

FIG. 1, cont'd—Light Curves of the 62 Variables.

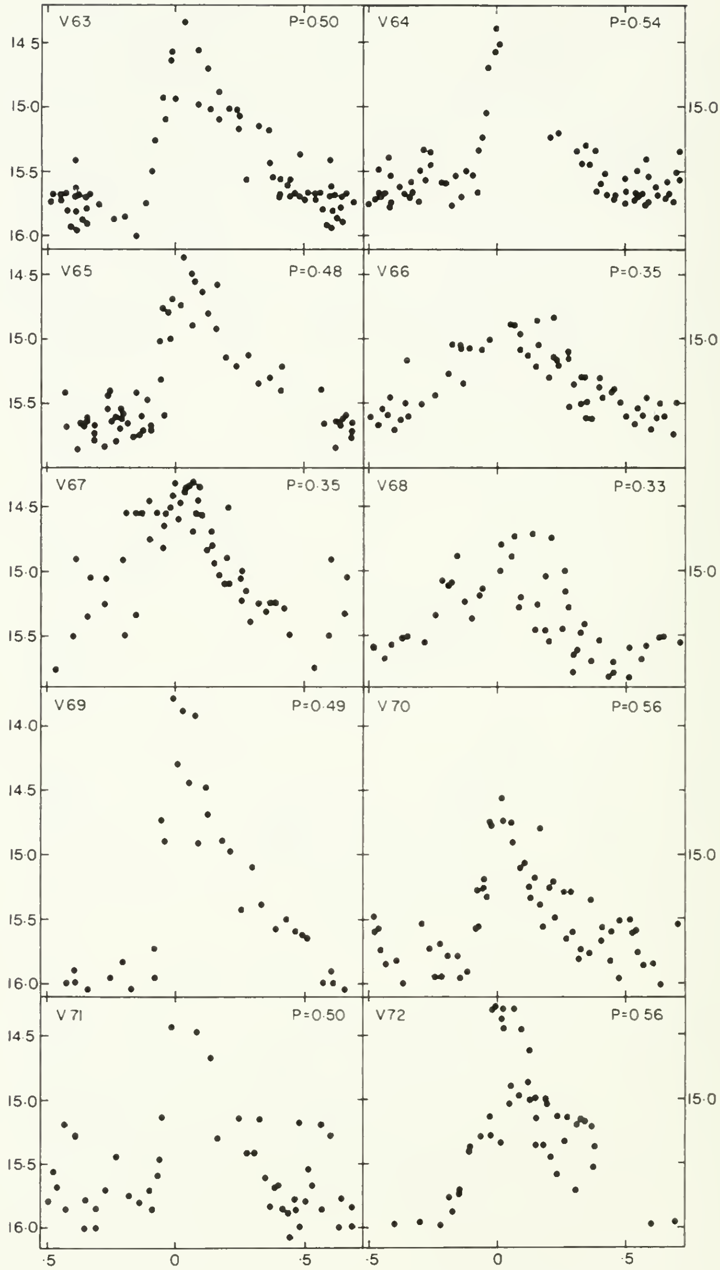

FIG. 1, cont'd—Light Curves of the 62 Variables.

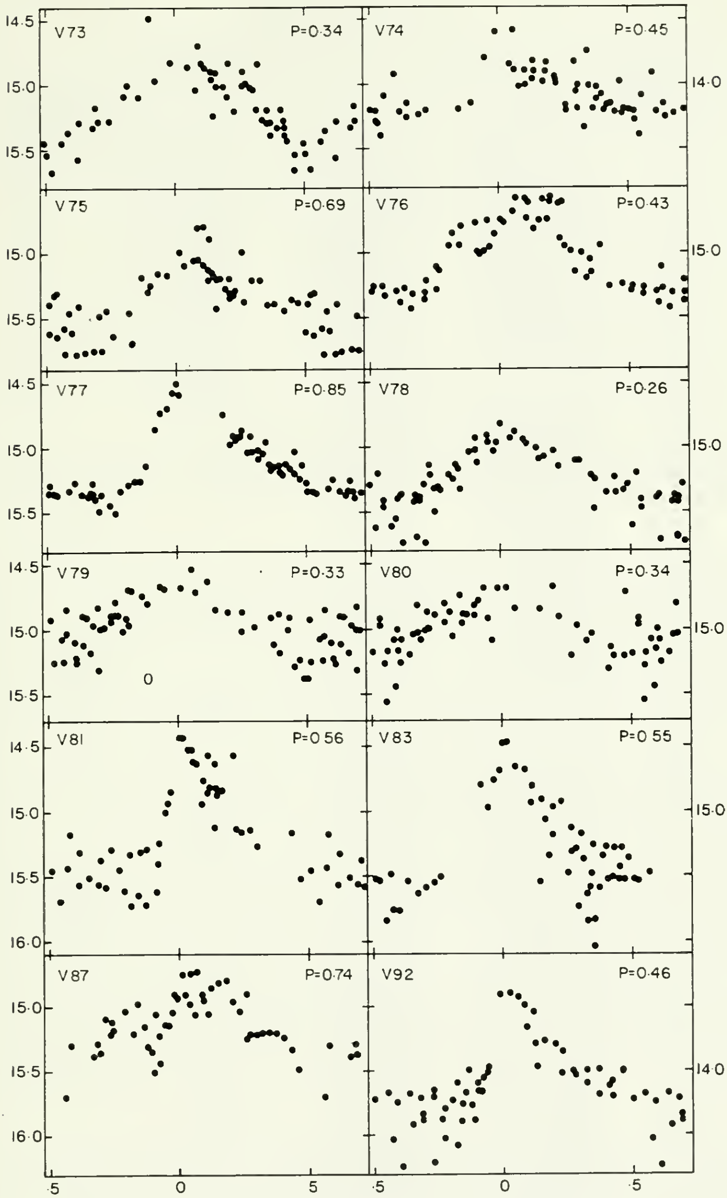

Fig. 1, cont'd—Light Curves of the 62 Variables.

TABLE II

Elements of the Variables

Var.	Epoch of Max.	Period	β	Comments on Period
1	21424.976	0.5217856		const
2	21424.886	0.526		
3	21424.937	0.6001832	0.04	
6	21424.744	0.5488311	−0.05	
7	21424.779	0.4943896	0.07	
8	21424.575	0.546224	0.09	
9	21424.739	0.698895		const
10	21424.852	0.5306628	−0.02	
11	21424.943	0.5958914		const
12	21424.621	0.4677144	−0.06	
13		0.5131223	0.04	
14	21424.726	0.4872423		
15	21424.693	0.3367607	0.03	
16	21424.406	0.6476223	0.12	
18	21424.631	0.46388		
19	21424.603	0.4699535	0.16	
20	21424.699	0.6094759		const
21	21424.876	0.6048941		const
25	21424.525	0.508		
27		0.4703		
28	21424.805	0.5439474	−0.13	
29	21424.584	0.4514334	−0.12	
30	21424.518	0.5921755		const
31	21424.560	0.3005826		const
32	21424.710	0.4577863		const
33	21424.616	0.5014722	0.04	
34		0.5681431		const
35	21424.548	0.3081197		
36		0.6277229		const
38	21424.927	0.4704441		
39	21424.881	0.5890346	0.05	
40	21424.762	0.3173286	0.03	
41	21424.538	0.4885749	−0.04	
42	21418.129	25.738		W Virginis
43	21424.689	0.6602264		const
44	21424.643	0.329		
45	21424.847	0.6166364		const
47	21424.978	0.5397295	−0.09	
52	21424.522	0.5017848		
55	21424.719	0.3288968	0.03	
58	21424.620	0.491265		
59	21424.712	0.5420259		const
61	21424.456	0.5686157	0.10	
62	21424.789	0.2814092		
63	21424.500	0.4976763	0.04	
64	21424.954	0.5445075	−0.13	
65	21424.902	0.480691		
66	21424.574	0.350682		
67	21424.681	0.3490462		
68	21424.647	0.3342797		
69	21424.881	0.4948743		const
70	21424.603	0.5585255	0.18	
71	21424.968	0.5024676	0.07	

TABLE II—*continued*

Var.	Epoch of Max.	Period	β	Comments on Period
72	21424.682	0.562		
73	21424.626	0.3401118	0.05	
74	21424.667	0.4539961	−0.06	
75	21424.639	0.6854136	0.07	
76	21424.663	0.432421	0.03	
77	21424.521	0.8451121	0.11	
78	21424.760	0.2648174		const
79	21424.548	0.3331387		const
80	21424.836	0.3365424	−0.02	
81	21424.647	0.5573235	−0.18	
83	21424.955	0.5533073		const
87	21424.736	0.7383888		const
92	21424.893	0.4635789		

Remarks to Table II

Vars. 13, 27, 34 and 36 were all studied on the David Dunlap plates by Coutts and Sawyer Hogg (1969), but were too crowded for measurement on the Mount Wilson 1917 plates.

was taken first. Both Dr. Shapley and Miss Henrietta Swope were consulted. The latter perused the Mt. Wilson records, but no definite decision was made. In constructing the Table it was assumed that the later exposure is the one to the west. This point is not of great importance because an average of the two was used in forming the light curves of the 62 variables which are shown in Figure I.

The curves, based on observations from eight different nights, are well defined and are therefore very useful for any studies of period changes of the variables. The periods adopted are the same as those used in Coutts and Sawyer Hogg (1969) and are listed in Table II, along with the epoch of maximum light for 1917. Also listed is β, the rate of period change, adopted from Coutts and Sawyer Hogg (1969) or Coutts (1969). Of the 61 RR Lyrae type stars, 46 are of type *a* and have periods ranging from 0.45 to 0.85 days and median 0.54 days. The other 15 are of type *c* with periods between 0.26 and 0.43 days and median 0.33 days. This is the period distribution for a cluster of the Oosterhoff type I.

This program has been supported by grants from the National Research Council of Canada to Dr. Helen S. Hogg. I am grateful to Dr. H. W. Babcock for the loan of the Mt. Wilson plates and to Mr. Basil Katem for making the necessary arrangements. It is a pleasure to thank Dr. Hogg for her invaluable guidance.

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May 26, 1971

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SPECTROSCOPIC ORBITS OF THE BINARY SYSTEMS H.D. 128661, AR Cas, β Ari and H.D. 209813

By Walter L. Gorza and John F. Heard

Abstract

From spectroscopic observations there have been obtained the orbital elements of two eclipsing binary systems (H.D. 128661, AR Cas) and two spectroscopic binaries (β Ari and H.D. 209813). For one system (H.D. 128661), no solution was previously available. The other systems are well known and were investigated for possible changes in their orbital elements. There seem to be no changes for AR Cas; a small change in the value of the longitude of periastron, ω, seems probable for β Ari; and there is some evidence of a change in the value of the semi-amplitude, K, for H.D. 209813.

Introduction

The spectrograms used during the present work were all obtained with the 12 Å/mm dispersion of the all-reflection grating spectrograph attached to the 74-inch telescope of the David Dunlap Observatory. The measurements were carried out on the Grant (AR Cas, β Ari and part of H.D. 128661) and Zeiss-Abbe (remaining plates for H.D. 128661 and H.D. 209813) comparators. Preliminary elements were derived by the use of a series of computed velocity-curves drawn by R. K. Young (except for β Ari, for which the Lehmann-Filhés method was used). Least-squares differential corrections were carried out on all the preliminary values by the use of a computer program written by D. Hube. The equation of condition derived by Lehmann-Filhés (1894) was used for all the systems, except for H.D. 209813 for which—its eccentricity, e, being so small—Sterne's (1941) method was used. The indicated errors are mean errors. The phases (given in the tables and used in the diagrams) are given in days relative to the finally adopted value for T, the time of periastron passage. Table IX (see page 110) shows the wavelengths used in obtaining the radial velocities for the four binary systems.

H.D. 128661

The variable radial velocity of this star ($\alpha = 14^h\ 33^m.1$, $\delta = +36°\ 22'$, $m_{ptg} = 6.97$, Sp. = A0) was first observed at the Simeis Observatory. Jackisch (1968) found that the star was probably an eclipsing variable with the minimum occurring at J.D. 2438906.455. Another minimum

was observed by Harris (1969) to occur at J.D. 2440362.9070. Following the report by Jackisch, the star was placed on our observing program and altogether 52 spectrograms were obtained between February 8, 1969 and April 17, 1970.

By counting our radial velocity measures with the above-mentioned times of minima it was possible to obtain a very accurate period of 3.33284(2) days. The assumption was made that both minima are primary minima. This assumption seems to be justified inasmuch as only one component is visible on the spectrograms. The differential correction was carried out only on five elements, the period being held fixed. The observations are listed in Table I. Figure 1 (see page 102)

TABLE I

Radial-Velocity Observations of H.D. 128661

J.D. 2440000+	V_0 km/sec	Phase from Final T	O-C km/sec
260.827	−44.6	0.676	+0.9
268.950	+43.0	2.133	+2.7
269.938	−77.3	3.121	+2.7
270.928	−31.2	0.778	+0.1
271.896	+49.1	1.746	+1.8
273.932	−74.6	0.449	+1.3
274.853	+32.7	1.370	+0.8
282.842	−11.7	2.694	+4.3
283.815	−86.1	0.334	+2.4
284.778	+27.1	1.297	+0.6
285.763	+32.8	2.282	+2.0
290.784	−49.1	0.637	+1.8
296.712	−91.0	3.232	+0.9
307.860	+5.6	1.049	+2.8
317.811	+0.4	1.001	+3.1
323.882	−79.2	0.407	+1.7
325.618	+41.0	2.143	+1.2
331.735	+46.9	1.594	+3.4
341.647	+39.2	1.507	−0.7
346.732	−93.1	3.260	+1.0
353.593	−100.6	0.122	−0.2
364.699	+20.9	1.229	0.0
365.588	+41.9	2.118	+0.9
367.613	−26.6	0.811	+0.3
368.597	+48.4	1.795	+0.7
371.620	+36.4	1.485	−2.4
437.607	−28.4	0.815	−2.1
438.590	+46.8	1.798	−0.9
456.572	−78.0	3.116	+1.4
458.572	+46.4	1.783	−1.3
459.583	−31.8	2.794	−0.6
462.578	+14.8	2.456	+0.2
610.809	−44.6	0.709	−3.8
625.823	+19.3	2.392	−1.9
625.949	+7.5	2.518	0.0
629.917	−85.8	3.153	−1.9
640.822	−40.2	0.727	−1.8
641.899	+47.5	1.804	−0.3

TABLE I—*continued*

J.D. 2440000+	V_0 km/sec	Phase from Final T	O-C km/sec
646.753	−99.7	3.325	−1.5
646.951	−100.4	0.190	−1.9
654.820	+32.0	1.393	−1.4
655.885	+12.4	2.458	−2.0
657.907	+12.1	1.147	−1.1
658.874	+39.9	2.114	−1.3
660.806	−42.0	0.714	−1.8
664.834	+32.3	1.409	−2.1
665.785	+22.7	2.360	−1.6
673.858	−77.5	0.434	+0.2
675.792	+20.8	2.368	−2.7
676.840	−103.0	0.083	−2.4
689.737	−62.7	2.982	−2.1
693.743	−89.2	0.322	+0.4

shows the individual observations and the adopted velocity curve. The mean error of a single observation was found to be ±1.8 km/sec. Table II lists the preliminary and the final values for the elements.

TABLE II

ORBITAL ELEMENTS OF H.D. 128661

Element		Preliminary	Final	
P	(days)	3.33284(2)	3.33284(2)	
T	(J.D.)	2440263.460	2440263.484	±0.003
ω	(°)	165	166.5	±0.3
e		0.15	0.137	±0.005
K	(km/sec)	75.3	74.2	±0.4
γ	(km/sec)	−15.9	−16.5	±0.3
a sin i	(10^6km)		3.37	±0.02
f(m)	⊙		0.137	±0.002

H.D. 221253 (AR Cas)

AR Cas (α = 23^h $25^m.4$, δ = +58° 00′, m_{ptg} = 4.89, Sp. = B3 V) was first observed to be a spectroscopic binary by Frost and Adams (1903). Photoelectric observations, first by Stebbins (1921), and then by Huffer and Collins (1962), show a similar value for the longitude of periastron, ω, while spectroscopic observations first by Baker (1909), then by Luyten, Struve and Morgan (1939) and Petrie (1944, 1962), show a changing value for ω, which would indicate a rotation of the line of apsides (Petrie, 1944).

Following receipt of Circular No. 1 for the "AR Cassiopeiae Coordination Programme", 44 spectrograms were here obtained between August 14, 1968 and September 12, 1969. The period of the system

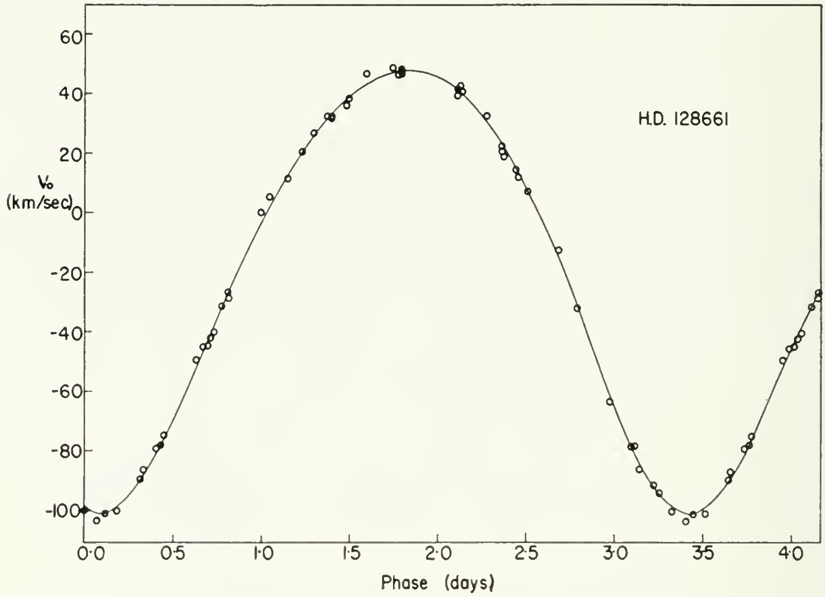

FIG. 1—Velocity Curve for the Eclipsing Binary H.D. 128661.

being known with great accuracy, it was held constant while the differential correction was carried out on the remaining five elements. The residuals were found to be reasonable except for those of three observations, which were made close to the time of the primary eclipse. It was easy to see that the radial velocities obtained at those points could have been influenced by the rotational velocity of the star itself (Batten, 1961), and accordingly they were removed. A new differential correction produced the final elements shown in Table IV. The observations are listed in Table III. Figure 2 shows the individual observations

TABLE III

RADIAL-VELOCITY OBSERVATIONS OF AR CAS

J.D. 2440000+	V_0 km/sec	Phase from Final T	O-C km/sec
82.730	−54.8	1.603	−2.8
83.716	−56.1	2.589	+0.3
84.590	−42.6	3.463	−2.7
95.773	−57.6	2.513	−0.5
98.706	+45.6	5.446	−3.4
100.825	−52.3	1.499	−2.9
102.925	−29.5	3.599	+6.4
103.710	−5.9	4.384	−0.5
104.849	+51.1	5.523	−0.5

TABLE III—*continued*

J.D. 2440000+	V_0 km/sec	Phase from Final T	O-C km/sec
106.827	−49.7	1.435	−2.2
107.731	−61.4	2.339	−3.3
108.693	−43.1	3.301	+1.1
111.812	+21.3	0.353	0.0
113.900	−53.4	2.441	+4.2
114.824	−46.7	3.365	−4.2
120.601	−52.6	3.076	−3.4
121.747	−11.7	4.222	+1.1
131.656	−56.2	1.998	+1.4
143.671	−57.5	1.881	−0.9
145.712	−32.3	3.922	−7.3
151.685	−27.9	3.828	+0.5
161.676	−54.5	1.687	−0.8
179.522	−41.5	1.334	+2.6
207.464	+29.6	5.010	+2.0
225.499	+18.8	4.846	+0.3
417.853	−50.7	3.078	−1.6
424.868	−20.9	4.027	+0.1
425.852	+29.5	5.011	+1.9
438.778	+52.2	5.804	−2.7
449.706	+5.8	4.599	+0.5
453.851	−50.4	2.678	+5.1
455.837	+8.5	4.664	−0.2
456.837	+60.3	5.664	+5.7
459.856	−52.3	2.617	+3.8
460.737	−36.1	3.498	+2.8
462.756	+49.2	5.517	−2.2
464.724	−45.2	1.418	+1.8
467.760	−1.7	4.454	+0.3
469.703	+24.1	0.331	+0.8
472.708	−44.8	3.336	−1.5
476.803	−44.4	1.365	+0.8
The following observations were not used to obtain the final solution.			
099.814	+8.1		
166.604	+13.8		
457.808	+18.8		

TABLE IV

ORBITAL ELEMENTS OF AR CAS

Element		Preliminary	Final	
P	(days	6.0663309	6.0663309	
T	(J.D.)	2440087.219	2440087.193	±0.013
ω	(°)	30	31.4	±0.8
e		0.22	0.245	±0.012
K	(km/sec)	56.5	56.7	±0.7
γ	(km/sec)	−10.3	−13.4	±0.5
a sin i	(10^6km)		4.59	±0.06
f(m)	$\odot$		0.095	±0.004

and the adopted velocity curve. The error of a single observation was found to be ± 2.8 km/sec.

It can be seen that the value for ω here obtained (that is, $\omega = 31^\circ\!.4$) and the identical result obtained by Petrie in 1958 (Batten, 1968), together with the two photoelectric solutions by Stebbins ($\omega = 37^\circ\!.25$), and by Huffer and Collins ($\omega = 34^\circ \pm 5^\circ$), seem to rule out the suggestion that there is a rotation in the line of apsides. If, nonetheless, small variations in the value of ω are real, then, the suggestion by Batten (1960, 1961) that a third body may be present in the system would explain these variations and the variations that Batten found in the value of V_0, the systemic velocity.

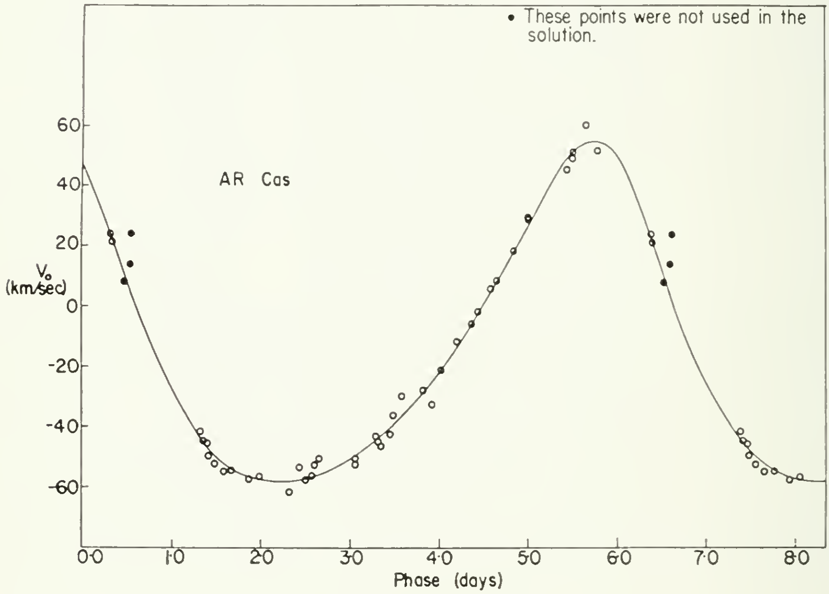

FIG. 2—Velocity Curve for the Eclipsing Binary AR Cas.

H.D. 11636 (β Ari)

The first spectroscopic orbital solution to this star ($\alpha_{1900} = 01^h\ 49^m\!.1$, $\delta = +20^\circ\ 19'$, $m_{ptg} = 2.86$, Sp. = A5) was obtained by Ludendorff (1907), and another by Petrie (1938). Because of the unusually large orbital eccentricity, Dommanget suggested that this may be an excellent system in which to observe the "periastron effect".

Following receipt of a list of binary stars in need of spectroscopic observation from Commissions 30 and 42 of the I.A.U., the star was

placed on our observing program and 44 plates were obtained between August 31, 1968 and June 11, 1970. (On two occasions three plates were obtained very close together in time and were combined into normal places.) Since the period of the system is so very close to an integral number of days, no observations can be made at the present time, of the maximum point in the velocity curve from observatories in North America. This point now crosses the meridian during daylight, and it will be the end of the century before it will again cross the meridian at a time when observations can be made, as it was at the time of Petrie's observations. For this reason our preliminary elements were obtained with the help of some of Petrie's observations near the maximum point of the velocity curve. The least-squares differential correction, however, was carried out only on our own observations. The value for the period (as given by Petrie) was held constant. The observations are listed in Table V, while Table VI gives the preliminary and the final elements. Figure 3 shows the individual observations and the adopted velocity curve. The error of a single observation was found to be ±2.3 km/sec.

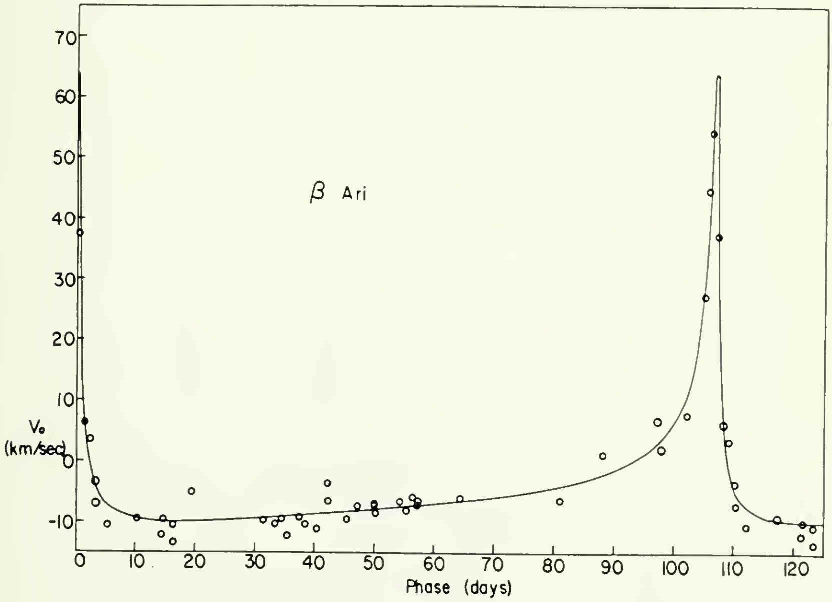

FIG. 3—Velocity Curve for the Spectroscopic Binary β Ari.

The value for ω obtained by Ludendorff is 21°88, that by Petrie 24°17 and the present one 20°01. Leaving aside Ludendorff's solution (only two lines at the most could be measured on each plate), and if the

TABLE V
RADIAL-VELOCITY OBSERVATIONS OF β ARI

J.D. 2440000+	V_0 km/sec	Phase from Final T	O-C km/sec
99.789	+27.6	105.385	−2.2
106.844	−10.6	5.443	−3.1
120.807	−4.8	19.406	+5.0
143.692	−3.4	42.291	+5.1
151.698	−8.6	50.297	−0.7
158.723	−7.0	57.322	+0.2
199.574	+2.3	98.173	−1.6
207.451	+45.1	106.050	+2.5
223.038	−9.4	14.639	+0.4
258.499	−7.1	50.100	+0.8
417.863	+8.0	102.467	−3.3
421.856	+54.6	106.460	−0.6
425.867	−6.9	3.474	−2.3
432.840	−9.3	10.447	+0.2
436.889	−12.1	14.496	−2.3
438.790	−10.5	16.397	−0.7
438.890	−13.3	16.497	−3.5
453.866	−9.7	31.473	−0.4
455.849	−10.6	33.456	−1.4
456.877	−9.5	34.484	−0.4
457.818	−12.2	35.425	−3.2
459.867	−9.2	37.474	−0.3
460.831	−10.4	38.438	−1.6
462.871	−10.9	40.478	−2.2
464.744	−6.5	42.351	+2.0
467.872	−9.5	45.479	−1.2
469.724	−7.3	47.331	+0.8
472.763	−7.2	50.370	+0.7
476.813	−6.5	54.420	+1.0
477.832	−7.9	55.439	−0.5
478.863	−5.6	56.470	+1.7
479.862	−6.5	57.469	+0.7
486.817	−6.1	64.424	+0.4
503.633	−6.3	81.240	−2.5
510.672	+1.5	88.279	+3.4
733.855	+7.1	97.467	+3.9
743.839	+37.4	0.454	0.0
744.839	+6.4	1.454	−0.9
745.849	+3.7	2.464	+4.8
746.851	−3.5	3.466	+1.1

TABLE VI
ORBITAL ELEMENTS OF β ARI

Element		Preliminary	Final	
P	(days)	106.9973	106.9973	
T	(J.D.)	2440208.286	2440208.398	±0.033
ω	(°)	25.5	20.0	±1.3
e		0.89	0.896	±0.003
K	(km/sec)	38.1	37.1	±0.9
γ	(km/sec)	−3.8	−4.0	±0.4
a sin i	(10^6km)		24.3	±0.7
f(m)	⊙		0.050	±0.004

criterion is used that only variations that exceed three times their probable error are real (Batten, 1968) then, since the mean error is $\pm 1^\circ\!.28$ (i.e. a probable error of $\pm 0^\circ\!.86$), it would appear that the variation in the value of ω—$41^\circ\!.6$ in 32 years—though small, may be real.

H.D. 209813

Four plates of this star ($\alpha = 22^h\,01^m0$, $\delta = +46^\circ\,45'$, $m_v = 6.52$, Sp. = KO III) taken at this Observatory in 1935–37 showed it to be a spectroscopic binary, and from 39 plates taken in 1945–46 the late Miss Ruth Northcott (1947) computed an orbit using a period of 24.431 days derived with the help of the first four plates. The 1945–46 plates were from the prism spectrograph with dispersion of 33 Å/mm. On six of her plates which were strong in the violet region Miss Northcott was able to see H and K lines in emission and to measure the velocities; they appeared to follow the velocities from the absorption lines.

Blanco and Catalano (1968) observed a slight variability of the light of H.D. 209813 to which they at first assigned a period of 25.98 days. Not being aware that the star had been studied as a spectroscopic binary, they suggested that the star was probably a Cepheid variable. Fernie, Hube and Schmidt (1968) of this Observatory replied that there were reasons to doubt the Cepheid explanation, and that the light variations should be re-examined relative to Miss Northcott's period to see if an explanation could be found in terms of an eclipsing system. At the same time we put the star on our spectroscopic observing program for a second orbit determination.

From a combination of our 30 1968–70 observations (which are listed in Table VII) and Miss Northcott's 1945–46 observations we have improved the period to 24.4284 days. We then solved for the remaining elements which are shown in Table VIII. Also in this table are listed the results of a new solution for Miss Northcott's observations which uses the improved period. Figure 4 shows our observations and the velocity curve representing our elements.

A comparison of the new elements from the 1945–46 observations and the elements from the 1968–70 observations calls for the following comments. In view of the smallness of the eccentricity the differences in the values of e and ω are not regarded as necessarily significant. The difference in γ, the systemic velocity, finds an easy explanation in the fact that different spectrographs were used. The difference of 1.5 km/sec in the value of K, the semi-amplitude, may be significant; it is about three times the mean error of either determination, and on a plot of the two sets of observations it was quite apparent. If it is indeed real it is tempting to think of an explanation in terms of mass transfer

TABLE VII

Radial Velocities and *H* and *K* Emission Widths

J.D. 2400000+	V_{abs} km/sec	Phase from Final T Days	O-C km/sec	V_{em}	Em. Width km/sec
39999.974	−60.1	7.231	−3.1	—	—
40099.719	−47.6	9.263	+0.4	−48.4	68
40100.786	−41.4	10.330	−0.9	−49.7	—
40103.663	−16.2	13.207	−0.5	−14.4	70
40104.630	−7.6	14.174	0.0	−8.5	63
40107.835	+10.2	17.379	+0.4	+10.1	60
40112.717	−2.6	22.260	+1.9	0.0	67
40120.651	−57.8	5.766	+0.2	−60.7	59
40125.773	−36.8	10.888	−0.8	—	—
40133.664	+13.1	18.779	+2.2	+10.9	61
40140.688	−32.4	1.375	+2.3	−36.2	67
40143.588	−56.2	4.275	−2.2	−58.7	—
40151.647	−23.6	12.334	−0.2	−23.5	62
40161.647	−2.4	22.334	+2.7	−6.4	66
40179.579	+3.1	15.838	−0.6	+0.8	64
40424.809	+6.8	16.784	−1.2	+6.2	62
40459.784	−49.2	2.902	−2.8	−46.2	65
40486.762	−57.1	5.451	+0.5	−58.1	—
40779.822	−55.6	5.370	+1.8	−63.4	—
40794.653	+8.2	20.211	+0.7	+14.0	—
40800.783	−39.4	1.903	−0.3	−40.9	68
40804.799	−57.0	5.919	+1.1	−57.7	75
40820.774	−5.8	21.894	−3.9	+3.6	57
40866.724	+9.2	18.987	−1.5	+13.1	—
40869.513	−0.7	21.776	+0.4	+9.6	69
40878.644	−57.1	6.479	+1.0	−54.0	64
40879.692	−55.2	7.527	+1.0	−57.5	68
40883.679	−27.8	11.514	+2.8	−31.3	57
40895.481	−13.4	23.315	−0.4	−11.2	73
40896.600	−23.4	0.007	−0.6	−20.5	70

TABLE VIII

Orbital Elements of H.D. 209813

Element		Preliminary	Final	Northcott's (re-computed)
P	(days)	$24^{d}.4284$	24.4284 ± 0.0005	24.4284 ± 0.0005
T	(J.D.)		2440017.170 ± 0.054	J.D. 2431661.692 ± 0.070
ω	(°)	0	89 ±15	73 ± 6
e		0	0.009 ± 0.003	0.026 ± 0.003
K	(km/sec)	35.3	34.6 ± 0.4	33.1 ± 0.6
γ	(km/sec)	−24.2	−23.6 ± 0.3	−22.2 ± 0.4
a sin i	(10^6km)		11.6 ± 0.2	11.1 ± 0.2
f(m)	$\odot$		0.105 ± 0.005	0.092 ± 0.005

The mean error of the period is estimated.

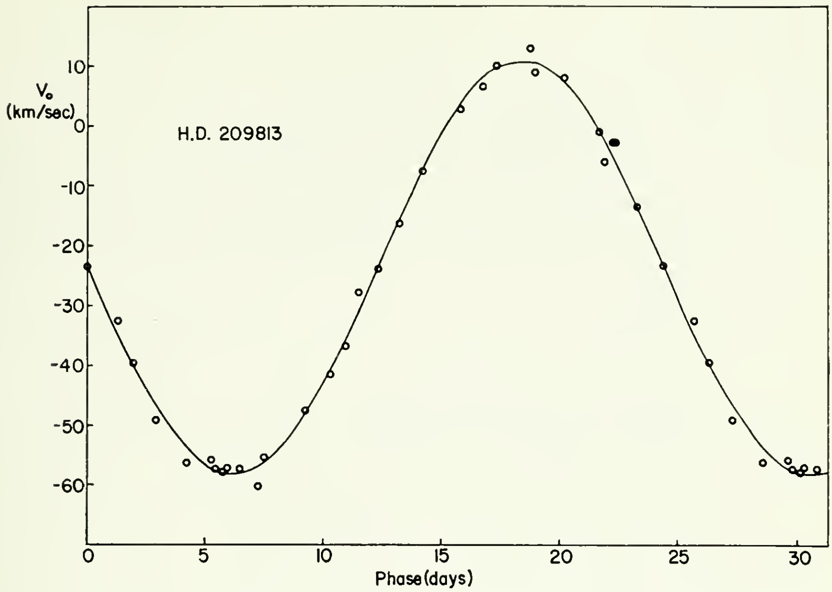

FIG. 4—Velocity Curve for the Spectroscopic Binary H.D. 209813.

between the components. Although it is difficult to belive that sufficient mass could be transferred in 24 years to affect the mass ratio by an observable amount, it may be that the elements are affected by a process of gas streaming which for this star changes its pattern with time. The idea that motion of this star's atmosphere plays a role in the measured radial velocities is suggested by the fact that a few of our residuals (O–C in Table VII) are larger than 2.5 km/sec. Such large residuals we have never encountered in our measures of spectrograms of standard-velocity stars with the 12 Å/mm spectrograph. Also the mean error of a single observation for H.D. 209813 is ± 1.6 km/sec compared with ± 1.1 km/sec for measures of standard-velocity stars.

We have been able to study the Ca II emission lines better than could Miss Northcott from her prism spectrograms. The velocities which we obtained from measures of H and K emission lines are listed in Table VII; the overall mean value of V_{abs}—V_{em} is -0.2 km/sec. Also we have measured the widths of the emission lines, the mean widths being listed in Table VII. The overall mean width is 65 km/sec. This gives for the star an absolute magnitude of $M_v = +0.8$ according to the correlation of Wilson and Bappu (1957). Neither the widths nor the differences between the H- and K- and the absorption-line velocities seem to correlate with the orbital period or any period near 24 days,

and, in fact, we believe that the widths are constant and that the velocity differences between emission and absorption lines are zero.

To return to the question of the light variability of H.D. 209813, Blanco and Catalano (1970) in the light of new observations have revised their period from 25.98 days to 25.3 days, but they state that their photometric observations are not at all satisfied by the orbital period, and that there are changes in the light curves of 1967 and 1968 and also apparent fluctuations in the period. For these and other reasons they reject the suggestion that the light variations are associated with eclipses.

A model to explain the light variability and its period remains to be

TABLE IX

List of Wave-Lengths used in the Determination of the Radial Velocity for:

H.D. 128661		AR Cas		β Ari		H.D. 209813	
Fe I	3820.428	H16	3703.855	H16	3703.855	Mn I	4034.490
Fe I	3825.884	H15	3711.973	H15	3711.973	Mn I	4035.728
Fe I	3859.913	H14	3721.940	H14	3721.940	Mn I	4041.361
Fe I	3865.526	H13	3743.370	H13	3734.370	Mn I	4055.543
Fe I	3920.260	H12	3750.154	H12	3750.154	Gd II	4078.444
Fe I	3922.914	H11	3770.632	H11	3770.632	Fe I	4156.803
Fe I	3927.922	H10	3797.900	H10	3797.900	Fe I	4174.917
Fe I	3930.299	He I	3819.606	Fe I	3820.428	Fe I	4187.044
Ca II	3933.664	H9	3835.386	H9	3835.386	Co I	4190.712
Al I	3944.009	H8	3889.051	Si II	3856.021	Fe I	4199.970
Sr II	4077.714	Hε	3970.075	H8	3889.051	Fe I	4202.031
Si II	4130.876	He I	4009.270	Ca II	3933.664	Fe I	4210.352
Fe I	4181.758	He I	4026.140	Sr II	4077.714	Fe I	4219.364
Fe I	4202.031	Hδ	4101.738	Hδ	4101.738	Fe I	4233.608
Sr II	4215.524	He I	4143.759	Sr II	4215.524	Fe I	4238.816
Fe I	4250.125	Hγ	4340.466	Hγ	4340.466	Fe I	4239.847
Fe I	4271.764	He I	4387.928	Mg II	4481.228	Fe I	4245.258
Fe I	4383.547	He I	4471.477	S II	4549.550	Fe I	4271.764
Fe I	4404.752	Hβ	4861.332	Hβ	4861.332	Fe I	4325.765
Ti II	4468.493					Cr I	4359.631
Ti II	4501.449					Fe I	4375.932
Fe II	4508.283					Fe I	4383.547
Fe II	4515.337					Fe I	4389.244
Ba II	4554.926					Gd II	4390.953
Ti II	4571.971					Fe I	4442.343
Fe II	4583.829					Fe I	4447.722
Fe II	4629.323					Fe I	4459.121
						Fe I	4466.554
						Fe I	4476.021
						V I	4496.864
						Cr I	4526.466
						Cr I	4527.339
						Fe I	4528.619
						Co I	4533.985
						Ba II	4554.033
						Cr I	4565.512
						Fe I	4602.944
						Fe I	4934.023

found. Probably a discussion in terms of gas streaming within the geometry of the Lagrangian surfaces would be illuminating in this regard. Meanwhile it seems clear that H.D. 209813 belongs to a group of spectroscopic binaries which all show greatly enhanced H and K emission (Hiltner 1947; Gratton 1950; Abt, Dukes, and Weaver 1969). Whether or not these other systems show light variability of the type seen in H.D. 209813 is important in determining a general model for their behaviour, and such an investigation is currently being carried out by Mr. William Herbst at this Observatory.

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and Ch. Fehrenbach, Observatoire de Haute Provence

ABSTRACT

Twenty-four stars of photographic magnitude 8.26 to 9.64 and of spectral types F, G and K, in the declination zone +25° to +30° have been investigated for suitability as an extension of the IAU lists of standard velocity stars. The stars were observed with dispersions of 12, 20 and 15 A/mm at the David Dunlap, Haute Provence and Dominion Astrophysical Observatories respectively, and the spectrograms were measured with systems tested against the IAU system. Three of the 24 stars are believed to have small-range velocity variations. The remaining 21 are presented as new IAU standard velocity stars.

INTRODUCTION

At IAU Symposium no. 30 on "Determination of Radial Velocities and their Application" (Batten and Heard 1967), Fehrenback drew attention to the need for an extension of the lists of IAU standard velocity stars to include stars which are appreciably fainter than those in Table 2 of the Report of Sub-commission 30a in the Transactions of the International Astronomical Union, vol IX, 1955.

In 1967 Heard reported to the IAU Commission 30 meeting in Prague the selection of 24 stars in the declination zone +25° to +30° with spectral types ranging from F7 to K5 and photographic magnitudes 8.26 to 9.64 which had already appeared to have constant velocities (Heard, 1956). He proposed to re-observe these stars at higher dispersion at the David Dunlap Observatory and invited participation by others.

OBSERVATIONS

Observations of the 24 stars were begun at the David Dunlap Observatory in 1968 and continued through 1971. The 12 A/mm dispersion of the Cassegrain grating spectrograph was used with the 188-cm telescope, and the goal was to obtain seven spectrograms of each star.

At l'Observatoire de Haute Provence Fehrenbach also undertook observations of these stars with the 20 A/mm dispersion of the coudé spectrograph of the 152-cm telescope, and in 1970 and 1971 obtained from three to five spectrograms of most of the stars.

Through the kindness of Dr. K.O. Wright and his colleagues, a total of 22 spectrograms of the stars were also obtained at the Dominion Astrophysical Observatory with the 15 A/mm dispersion of the Cassegrain grating spectrograph of the 183-cm telescope.

The results which follow are based on these three sets of observations which include a total of 277 spectrograms of the program stars. In addition,

133 spectrograms of existing IAU standard velocities stars were measured to ensure that the new velocities conform to the IAU system.

After reporting our preliminary results at the meeting of IAU Commission 30 in 1970, we were authorized to present the final results as IAU standards.

MEASUREMENT AND REDUCTION

David Dunlap

The Dunlap plates were measured on a Jenna Abbe comparator, four settings being made on both iron arc comparison lines and star lines in each direction of traverse. The star lines were a selection (usually between 20 and 28 in number) of the wavelengths listed by Gorza and Heard (1971). The reductions were made either by the usual method of tables of standard settings and correction curves or by a computer program which effectively establishes the dispersion curve of each spectrogram. We compared the two methods and found that the difference seldom exceeded 0.1 km/sec.

Although our lists of lines had been, in the first place, selected with care as a result of measurements of IAU standard velocity spectrograms, we feared that the special conditions of observation of the faint program stars (projected slit width 33μ, projected slit length 0.3 mm, long exposures and sometimes large hour angles) might introduce systematic errors. In an effort to determine such errors if they existed, we observed IAU standard velocity stars almost nightly under conditions similar to those for the program stars, attempting to match the quality of the spectrograms. Fifty-six such standard velocity spectrograms were measured and reduced. The results are summarized in Table 1 which lists, for F-, G- and K-type spectra separately, the residuals in the sense IAU-DDO and the average corrections which are applicable to our velocities to bring them to the IAU system. Although the mean errors of these corrections reveal them to be only marginally significant, we did nevertheless apply these small corrections to the Dunlap program star velocities.

A study of the standard velocity results failed to reveal any correlations of residuals with length of exposure, hour angle, plate density or seeing.

Dominion Astrophysical

Of the 22 available DAO 15 A/mm spectrograms of the program stars, 11 were taken with the spectrograph fitted with a conventional slit and the remaining 11 with the use of a Richardson image-slicer. Because these plates became available to us before a standard system of selected wavelengths had been made by the DAO astronomers, we used the wavelengths which had been selected for the DDO 12 A/mm spectrograms, and, to determine the systematic corrections which might thus be introduced, we measured six spectrograms of each of F-, G- and K-type standard velocity stars taken with the conventional slit. The results for the 18 spectrograms gave an average residual (IAU-DAO) of -0.8 ± 0.3. This agrees well with the findings of Aikman (1971) who got a residual of about this same amount for DAO

standard velocity spectrograms, measuring them in a different manner with a different wavelength selection. The samples used by both us and Aikman were too small to give a significant break-down of the residuals by spectral class. Accordingly, we corrected the measured velocities of all 11 of the conventional-slit spectrograms of program stars by −0.8 km/sec.

Aikman also reported a test of image-slicer standard velocity spectrograms and found no statistically significant mean residual for them. We tested our measures of the image-slicer program star spectrograms by re-computing the velocities according to the wavelengths used by Aikman and found the mean residual to be only 0.1 km/sec. Accordingly, we made no corrections to our measured velocities for these image-slicer spectrograms.

Haute Provence

The methods of measurement and reduction of the Haute Provence 20 A/mm spectrograms have been described by Fehrenbach (1972) who also analysed the results from 59 spectrograms of IAU standard velocity stars. Because he found the residuals, IAU-OHP, to be small and statistically insignificant, we have applied no corrections to the Haute Provence velocities of the program stars.

RESULTS

The results for the 24 program stars are summarized in Table II.

Column 1 gives the designation and (for the three stars not listed in Table III as new standards) the 1950 co-ordinates, the photographic magnitude and the spectral classification, the last two data being quoted from the results of Heard (1956).

Columns 2, 5, 8 give the Julian dates of the observations. Columns 3, 6, 9 give the velocities (corrected to the IAU system as indicated earlier), and columns 4, 7, 10 give the internal mean errors, i.e.

$$\varepsilon_1 = \sqrt{\frac{\Sigma\, v^2}{n\,(n-1)}}\ ,$$

where n is the number of lines measured and v is the deviation of the velocity of a line from the mean velocity for the plate.

Below the plate velocity entries in columns 2, 5, 8 are given the mean velocities from each observatory followed by the external mean errors, i.e.

$$\varepsilon_2 = \sqrt{\frac{\Sigma\, V^2}{N\,(N-1)}}\ ,$$

where N is the number of spectrograms and V is the deviation of the velocity of a plate from the mean velocity for the N plates.

Three stars, namely BD + 29° 1553, HD 160952 and HD 204934 show sufficient evidence of small-range variation of velocity to warrant their exclusion from the list recommended as new standards of velocity.

The new list of 21 IAU standard velocity stars is given in Table III.

Finally, we have the following comments on the results which we believe support their validity:

Our observations having been carried out over at least two years and more often three, there seems to be little chance that long-period variations have been missed.

For the determinations at the three observatories considered separately, the average values of the external mean errors per star are DDO ± 0.5, OHP ± 0.5, DAO ± 0.7, whereas the average values of the residuals between observatories are DDO-OHP = −0.2, DDO-DAO = +0.2. These residuals, then, seem not to be statistically significant.

Comparing the average external mean error per star in the list of IAU standard velocity stars fainter than magnitude 4.3 as given in IAU Transactions vol. IX p. 443 (after converting from P.E. to M.E.) with ours, we find that ours is somewhat better (0.34 compared to 0.44) in spite of the fact that the average number of observations per star is greater in the IAU list than in ours.

ACKNOWLEDGEMENTS

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TABLE I

RADIAL VELOCITY RESIDUALS FROM IAU STANDARDS
MEASURED ON DUNLAP SPECTROGRAMS

F-type			G-type			K-type		
HD	Sp.	IAU-DDO km/sec	HD	Sp.	IAU-DDO km/sec	HD	Sp.	IAU-DDO km/sec
22484	F8 V	+0.3	65583	G8 V	−1.6	3712	K0 II-III	+1.1
		+0.9						
			84441	G0 II	+1.5	3765	K2 V	+1.1
36673	F0 Ib	+1.3						
			103095	G8 V	+0.9	9138	K4 III	+1.3
89449	F6 IV	+1.2			−0.9			+0.1
		−2.0						+1.4
		+0.7	109379	G5 III	+0.5			+1.6
		−0.1			−0.4			+1.8
		+0.1						+0.6
			171391	G8 III	−0.5			+0.6
102870	F8 V	+0.2			−1.4			−0.6
136202	F8 IV	+0.3	204867	G0 Ib	+0.3	26162	gK1	+0.7
		+0.3			+0.3			
					+1.5	29139	K5 III	−1.8
187691	F8 V	+0.8			−0.6			+1.3
					−0.6			
222368	F7 V	+0.6			+1.5	35410	K0 III	0.0
					+0.4			0.0
								+1.6
						66141	K2 III	+1.5
								−2.0
								−1.7
								−0.2
								−1.7
								−0.4
						92588	K1 IV	−1.5
						107328	K0 III	−0.8
						186791	K3 II	+1.5
						212943	K0 III	−0.1
								+0.7
13 plates, mean +0.3 ±0.2			15 plates, mean 0.0 ±0.1			28 plates, mean −0.2±0.2		

TABLE II

RADIAL VELOCITY MEASURES OF THE PROGRAM STARS

STAR	DAVID DUNLAP			HAUTE PROVENCE			DOMINION ASTROPHYSICAL		
	J.D. 244. . .	Vel. km/sec	ε_1	J.D. 244. . .	Vel. km/sec	ε_1	J.D. 244. . .	Vel. km/sec	ε_1
HD 4388	0525.7	−30.0	0.6	0856.5	−29.5	0.5			
	0532.6	−28.4	0.5	0858.5	−27.0	0.7			
	0571.6	−32.2	0.6	0862.5	−25.9	0.5			
	0784.2	−27.3	0.6						
	0793.2	−26.2	0.6						
	0834.7	−28.0	0.5						
	0849.8	−28.7	0.4						
		−28.7	±0.7		−27.5	±1.0			
HD 12029	0578.6	+37.1	0.8	0850.5	+37.8	0.5	0480.0	+39.1	0.6
	0804.8	+38.3	0.6	0851.6	+38.1	0.6			
	0806.9	+38.1	0.2	0853.5	+43.7	0.5			
	0834.8	+37.4	0.3	0873.0	+36.8	0.5			
	0875.5	+39.7	0.5	0874.6	+38.1	0.6			
	0923.5	+39.6	0.4						
		+38.5	±0.4		+38.9	±1.2		+39.1	
HD 14969	0621.5	−32.6	0.4	0852.6	−33.0	0.7			
	0849.8	−35.2	0.5	0862.6	−32.6	0.5			
	0895.7	−32.6	0.8	0866.5	−33.2	0.9			
	0951.5	−34.9	0.3	0873.6	−32.5	0.8			
	0953.5	−32.5	0.4						
	0958.5	−34.9	0.5						
		−33.8	±0.6		−32.8	±0.2			
HD 23169	0578.7	+12.9	0.9	0858.6	+14.2	0.5			
	0594.7	+12.6	0.8	0872.6	+14.0	0.5			
	0624.6	+13.2	0.7	0873.5	+14.8	0.3			
	0640.6	+13.5	0.8	0874.5	+13.3	0.5			
	0927.8	+13.0	0.9	0892.6	+12.8	0.4			
	0951.5	+11.9	0.7						
	0953.5	+13.0	0.5						
	0993.5	+14.2	0.6						
		+13.0	±0.3		+13.8	±0.4			
HD 32963	0223.7	−64.0	0.8	0855.6	−60.0	0.6			
	0259.5	−62.2	0.6	0857.6	−64.0	0.6			
	0266.5	−63.4	0.6	0866.5	−64.5	0.4			
	0624.7	−63.7	0.5	0872.6	−63.7	0.4			
	0849.9	−64.2	0.4	0874.6	−62.4	0.6			
	0941.8	−63.4	0.6	1190.6	−60.8	0.4			
	0942.7	−64.1	0.7						
		−63.6	±0.3		−62.6	±0.7			

TABLE II—*continued*

STAR	DAVID DUNLAP			HAUTE PROVENCE			DOMINION ASTROPHYSICAL		
	J.D. 244. . .	Vel. km/sec	ε_1	J.D. 244. . .	Vel. km/sec	ε_1	J.D. 244. . .	Vel. km/sec	ε_1
HD 42397	0259.6	+38.1	0.4	0872.6	+36.5	0.5	1026.7	+35.3	0.6
	0270.7	+36.2	0.5	0873.7	+37.0	0.4			
	0280.6	+40.5	0.6	0892.7	+39.4	0.5			
	0660.6	+36.9	0.7	0893.6	+36.9	0.5			
	1001,5	+37.3	0.8						
	1015.5	+37.6	0.6						
	1020.5	+37.0	0.7						
		+37.7	±0.5		+37.5	±0.7		+35.3	
BD+29°1553	0259.7	−7.8	0.6						
$07^h31.^m4$	0657.6	+1.2	0.9						
+28°51′	0665.6	+0.5	0.6						
9.29	0675.6	−2.0	0.7						
GO IV	0681.6	−1.8	0.9						
	0951.8	−5.4	0.6						
		Var.							
HD 65934	0207.8	+34.7	0.3	1051.3	+36.5	1.3			
	0280.7	+35.4	0.3	1052.3	+35.1	0.8			
	0595.8	+34.8	0.4	1053.3	+35.3	0.7			
	0658.6	+33.4	0.7						
	0662.5	+34.3	0.5						
	0927.9	+33.9	0.3						
	0955.7	+36.2	0.3						
		+34.7	±0.4		+35.6	±0.4			
HD 75935	0207.8	−19.8	0.4	1052.3	−19.3	0.8			
	0308.6	−19.8	0.5	1053.4	−20.4	1.0			
	0624.8	−19.1	0.4	1055.3	−18.9	0.5			
	0641.8	−16.9	0.8						
	0700.6	−18.8	1.2						
	1015.6	−17.9	0.9						
	1020.6	−18.2	0.6						
		−18.6	±0.4		−19.5	±0.4			
HD 86801	0269.8	−14.3	0.5	1052.4	−13.0	0.7	0943.0	−12.7	0.6
	0273.8	−15.6	0.7	1052.4	−14.9	0.7	1026.8	−17.1	0.4
	0318.6	−14.5	0.6	1053.4	−15.7	0.9	1035.8	−13.6	0.5
	0665.7	−12.6	0.6				1075.7	−14.8	0.4
	0971.9	−16.8	0.6						
	1015.7	−12.4	0.9						
	1022.7	−15.4	0.8						
		−14.5	±0.7		−14.5	±0.8		−14.5	±1.0

TABLE II–*continued*

STAR	DAVID DUNLAP			HAUTE PROVENCE			DOMINION ASTROPHYSICAL		
	J.D. 244. . .	Vel. km/sec	ε 1	J.D. 244. . .	Vel. km/sec	ε 1	J.D. 244. . .	Vel. km/sec	ε 1
HD 90861	0208.9	+36.2	0.4	1051.4	+37.7	1.3			
	0579.9	+36.4	0.3	1051.4	+36.4	0.8			
	0583.9	+36.7	0.3	1051.4	+36.5	0.8			
	0592.9	+36.3	0.3	1055.4	+34.2	1.0			
	0657.7	+36.9	0.3						
	0694.6	+38.8	0.6						
	0928.0	+33.5	0.5						
		+36.4	±0.6		+36.2	±0.7			
HD 102494	0208.0	−22.3	0.4	1051.4	−21.6	0.8	9902.9*	−24.8	0.6
	0209.0	−22.8	0.3	1051.4	−21.7	1.2	9993.9*	−24.0	0.4
	0257.7	−24.9	0.5	1055.4	−21.6	0.5	0245.0	−21.7	0.5
	0951.9	−24.3	0.6	1101.4	−22.4	0.7	1044.8	−22.9	0.5
	0967.9	−23.4	0.4	1110.4	−23.4	1.0	1063.9	−22.1	0.6
	1024.8	−21.8	1.2				1068.7	−22.5	0.7
	1027.8	−24.1	0.9						
		−23.4	±0.4		−22.1	0.3		−23.0	±0.4
HD 112299	0260.0	+6.8	0.6	1100.4	+3.0	0.6	0724.8	+3.3	0.4
	0266.7	+1.9	0.5	1101.4	+3.1	0.6	1029.9	+3.1	0.5
	0268.8	+5.0	0.6	1134.4	+2.3	0.6			
	0308.7	+3.8	0.4						
	0681.7	+1.4	0.9						
	0713.6	+2.3	1.0						
	0724.6	+1.3	1.0						
	0726.6	+7.0	0.9						
		±3.7	±0.8		+2.8	±0.3		+3.2	±0.2
HD 122693	0268.9	−4.8	0.3	1100.5	−7.3	0.7	9999.8*	−6.6	0.4
	0584.0	−6.5	0.5	1101.5	−5.2	0.5	1068.8	−5.7	0.5
	0606.9	−7.2	1.2	1102.4	−7.0	0.5			
	0657.8	−6.4	0.3	1111.4	−7.3	0.7			
	0710.8	−6.7	0.7						
	0725.8	−5.5	0.4						
	1035.8	−5.5	0.6						
		−6.1	±0.4		−6.7	±0.5		−6.2	±0.5
HD 132737	0270.8	−24.9	0.4	1101.5	−24.0	0.7	0734.7	−22.5	0.7
	0304.0	−24.8	0.5	1111.4	−23.6	0.8	1068.8	−27.4	0.6
	0624.9	−24.4	0.3	1136.4	−24.0	1.0			
	0657.9	−24.9	0.4	1143.4	−23.5	0.8			
	0726.7	−23.8	2.2						
	0727.6	−23.2	0.5						
	0743.7	−22.7	0.4						
		−24.1	±0.3		−23.8	±0.1		−25.0	±1.9

*J.D. 243 . . .

TABLE II–*continued*

STAR	DAVID DUNLAP			HAUTE PROVENCE			DOMINION ASTROPHYSICAL		
	J.D. 244. . .	Vel. km/sec	ε_1	J.D. 244. . .	Vel. km/sec	ε_1	J.D. 244. . .	Vel. km/sec	ε_1
HD 140913	0308.9	−21.2	0.6	1110.5	−18.0	0.4	9999.8*	−22.3	0.7
	0681.8	−19.1	0.7	1111.4	−18.1	0.4			
	0724.8	−22.6	0.8	1134.4	−21.5	0.7			
	0734.7	−20.1	0.6	1141.4	−20.8	0.7			
	0746.6	−21.1	0.6	1142.4	−21.9	0.8			
	0750.6	−20.8	0.4						
	1022.9	−22.8	0.7						
		−21.1	±0.5		−20.1	±0.8		−22.3	
HD 149803	0303.9	−7.0	0.6	1147.4	−9.2	0.7	0734.9	−6.1	0.9
	0367.8	−7.0	0.6	1148.4	−8.0	0.5			
	0734.8	−9.7	0.6	1149.4	−8.9	0.6			
	0735.7	−8.0	0.6						
	0745.7	−8.3	0.7						
	0760.6	−4.6	0.4						
	1015.9	−6.9	0.6						
		−7.4	±0.6		−8.7	0.4		−6.1	
HD 160952	0368.7	+20.9	0.5	1110.5	+22.5	0.9	9999.9*	+22.4	0.4
17^h39^m7	0444.7	+29.1	0.6	1111.5	+23.2	0.9			
$+29°37'$	0453.6	+29.2	0.7	1134.5	+24.8	0.7			
9.04	0455.6	+28.7	0.3	1136.4	+24.2	0.9			
G8 III	0736.7	+24.6	0.4						
	0759.6	+23.5	0.5						
		Var.							
HD 171232	0116.6	−35.2	0.3	0855.4	−36.9	0.5			
	0410.7	−36.5	0.6	0865.3	−37.8	0.4			
	0413.8	−38.2	0.4	0866.4	−36.7	0.6			
	0727.7	−33.6	0.3	1111.5	−36.0	0.9			
	0735.8	−38.9	0.6	1136.4	−32.4	0.9			
	0746.8	−34.2	0.6						
	0751.7	−35.1	0.5						
	0758.7	−35.6	0.4						
		−35.9	±0.7		−36.0	±0.9			
BD+28°3402	0504.5	−37.7	0.7						
	0525.5	−37.1	0.6						
	0759.7	−36.6	0.5						
	0760.7	−33.8	0.9						
	0793.7	−37.1	0.7						
	0800.6	−36.2	0.4						
	0804.7	−37.5	0.6						
		−36.6	±0.5						

*J.D. 243 . . .

TABLE II–*continued*

STAR	DAVID DUNLAP			HAUTE PROVENCE			DOMINION ASTROPHYSICAL		
	J.D. 244. . .	Vel. km/sec	ε_1	J.D. 244. . .	Vel. km/sec	ε_1	J.D. 244. . .	Vel. km/sec	ε_1
HD 194071	0418.7	−9.5	0.5	0857.4	−9.1	0.4			
	0425.7	−9.8	0.4	0861.4	−9.6	0.6			
	0751.8	−9.8	0.3	0865.4	−9.9	0.3			
	0758.8	−9.6	0.5	1136.5	−10.6	0.9			
	0773.7	−8.9	0.3	1138.6	−11.0	0.8			
	0774.7	−10.2	0.4						
	0834.6	−9.3	0.5						
		−9.6	±0.2		−10.0	0.3			
HD 204934	0546.5	−3.3	0.4	0873.3	−11.7	0.4			
$21^h29^m.0$	0547.5	−6.3	0.7	1134.5	−6.6	1.1			
$+28^o09'$	0806.7	+0.4	0.3	1191.3	−4.7	0.8			
K1 III	0861.7	−11.5	0.9						
		Var.			Var.				
HD 213947	0116.7	+16.7	0.3	0852.5	+18.2	0.7	0479.9	+16.3	0.9
	0504.6	+17.3	0.6	0856.4	+15.8	0.5			
	0525.6	+15.7	0.6	0864.4	+16.4	0.6			
	0759.8	+16.1	0.5	0893.3	+17.3	0.6			
	0774.8	+16.8	0.6	1134.6	+18.7	1.5			
	0762.7	+14.6	0.6	1136.6	+17.4	1.3			
		+16.2	±0.4		+17.3	±0.4		+16.3	
HD 223094	0116.8	+19.5	0.4	0864.4	+20.0	0.6			
	0504.7	+19.7	0.7	0864.5	+19.8	0.9			
	0525.7	+19.6	0.2	0866.4	+21.0	0.6			
	0532.6	+19.1	0.4	0867.4	+18.9	0.7			
	0576.5	+16.8	1.2	0874.4	+20.0	0.6			
	0784.8	+21.9	0.3	1134.6	+18.8	1.1			
	0806.8	+19.9	0.5						
		+19.5	±0.6		+19.8	±0.3			

TABLE III

21 NEW IAU STANDARD VELOCITY STARS

HD or BD	α(1950) h m	δ(1950) ° ′	Ptg. Mag.	Sp.	Vel. km/sec	M.E.	No. of Obs.
4388	00 43.8	+30 41	8.80	K3 III	−28.3	0.6	10
12029	01 55.8	+29 08	8.96	K2 III	+38.6	0.5	12
14969	02 22.6	+29 39	8.96	K3 III	−33.4	0.3	10
23169	03 40.9	+25 34	9.39	G2 V	+13.3	0.2	13
32963	05 04.8	+26 16	8.36	G2 V	−63.1	0.4	13
42397	06 08.5	+25 01	8.68	G0 IV	+37.4	0.4	12
65934	07 59.1	+26 47	8.87	G8 III	+35.0	0.3	10
75935	08 50.9	+27 06	9.35	G8 V	−18.9	0.3	10
86801	09 58.7	+28 48	9.48	G0 V	−14.5	0.4	14
90861	10 27.1	+28 50	8.36	K2 III	+36.3	0.4	11
102494	11 45.3	+27 37	8.26	G8 IV	−22.9	0.3	18
112299	12 53.0	+26 01	9.19	F8 V	+ 3.4	0.5	13
122693	14 00.5	+24 48	8.74	F8 V	− 6.3	0.2	13
132737	14 57.7	+27 21	9.03	K0 III	−24.1	0.3	13
140913	15 43.1	+28 37	8.81	G0 V	−20.8	0.4	13
149803	16 33.9	+29 51	8.90	F7 V	− 7.6	0.4	11
171232	18 30.6	+25 27	8.66	G8 III	−35.9	0.5	13
28° 3402	19 33.0	+28 59	9.55	F7 V	−36.6	0.5	7
194071	20 20.5	+28 05	9.06	G8 III	− 9.8	0.1	12
213947	22 32.3	+26 20	8.93	K4 III	+16.7	0.3	13
223094	23 43.9	+28 26	8.97	K5 III	+19.6	0.3	13

David Dunlap Observatory,
Richmond Hill, Ontario,
October, 1972.

PUBLICATIONS OF
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VOLUME 3 NUMBER 6

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INTRODUCTION

This is the third in the series of catalogues of variable stars in globular clusters published by the David Dunlap Observatory. The first appeared in 1939 (David Dunlap Publications, vol. 1, no. 4) and the second in 1955 (vol. 2, no. 2). In addition, a catalogue of variables in globular clusters south of $-29°$ declination was published in 1966 at Cordoba by C. R. Fourcade and J. R. Laborde, along with a splendid atlas of photographic prints of clusters prepared by J. Albarracin.

A preliminary edition of this Third Catalogue, in manuscript form, comprising 2057 entries, was circulated at the IAU Colloquium no. 21, "Variable Stars in Globular Clusters and in Related Systems," in August 1972. Investigators were invited to send corrections and additions to the author of the manuscript by October 2, 1972. The cut-off date for material included in this publication is November 1, 1972. Considerable new material was received, much of it from the Colloquium itself. This led to extensive revisions in the manuscript and some delay in its publication. Some of the conclusions drawn from the material of the Third Catalogue are in press in the Colloquium volume edited by J. D. Fernie.

SUMMARY OF DATA ON VARIABLES IN GLOBULAR CLUSTERS

At present a recorded search for variables in 108 of the approximately 130 globular clusters belonging to our galaxy has been made. This search has yielded 2119 variables. Certainly variables do not abound in most globular clusters. Of the 108 clusters that have been examined, only 10 contain more than 50 variables each, and 81 contain fewer than 20 variables each. At the time of compilation of the Second Catalogue, from the distribution it appeared that the most frequent number of variables found in a globular cluster was one. Now, from the data in the Third Catalogue, the most frequent number is zero. There are effectively 13 clusters with no variables, if one includes NGC 6397, whose three variables are considered field stars. One variable alone is found in each of 10 clusters.

Figure 1 shows the frequency distribution of the number of variables per cluster. More than 60 per cent of the clusters examined, 65 in all, have 10 variables or fewer; exactly 25 per cent, 26 clusters, have more than 20 variables; and 5 clusters have approximately 100 or more. The richest cluster still remains NGC 5272, Messier 3, with 212 variables. The second richest is Omega Centauri, NGC 5139, with 179. Next in order of richness is IC 4499, a newcomer in this catalogue, less than $10°$ from the southern celestial pole, with 129 discovered by Fourcade and Laborde, and 41 suspected. Messier 15, NGC 7078, with 111 and Messier 5, NGC 5904, with 97 complete this list of exceptionally rich clusters.

One of the problems faced in compiling this catalogue was to decide whether to include or exclude field variables. In general my policy has been to number those variables which lie within the obvious confines of a cluster, even though some of them are manifestly field stars. To omit them would ultimately lead to confusion. On the other hand, work of recent years in the surroundings of globular clusters has shown that

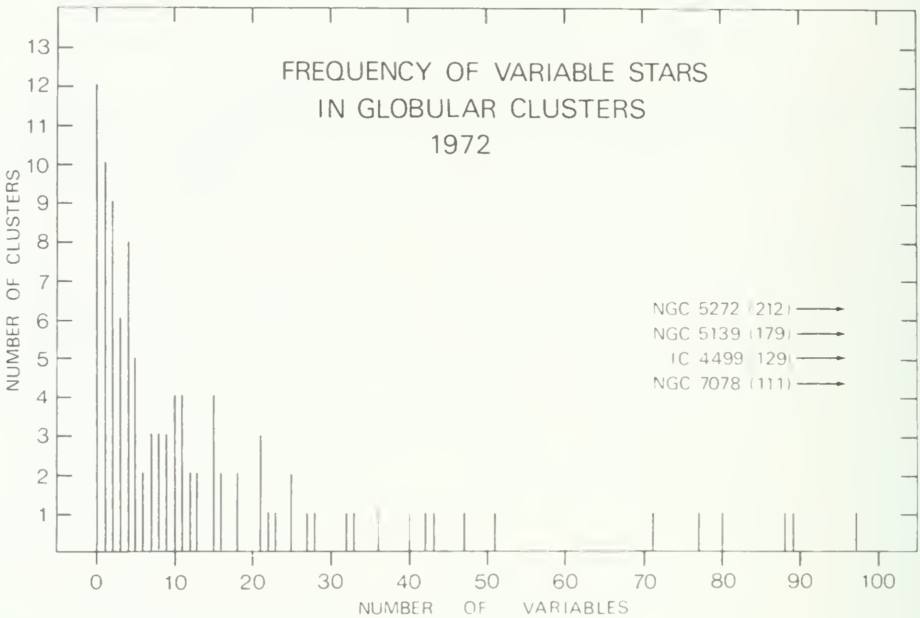

Figure 1 Distribution of the known, published variables per cluster.

some of the RR Lyrae stars well beyond their confines are likely members, or were so in the past. These stars are not included among the numbered variables of a cluster, except in a few cases.

NUMBERS OF TYPES OF VARIABLES AND KNOWN PERIODS

Of the known variables, periods have now been determined for 1313 in 55 clusters, compared with 843 in 38 clusters in 1955. In many clusters some periods have been revised or redetermined. In some cases there are only minor changes in the fifth or higher decimal places, but in others the change is major, even in the first decimal, giving an alternate period. In addition, many determinations of period changes have now been made. An effective summary of such changes in a concise catalogue is not possible, and the reader is referred to the original papers for pertinent data.

Table I gives a summary of the numbers and types of variables and numbers of periods known in the 108 globular clusters for which there is a record of search. For further particulars about these stars, such as cluster membership, the reader is referred to the catalogue itself.

The first column of the table gives the customary designation of the cluster, usually the NGC number. The second gives the total number of variables, and the third the total number of known periods. Periods for RR Lyrae stars are counted as known even when the published value is questionable or there is an alternate period, providing at least two decimals are given; and for semiregular variables if a numerical value of the cycle has been published. The fourth column gives the number of RR Lyrae periods

TABLE I

Summary of Variable Stars in Globular Clusters

NGC	Total variables	Total periods	RR Lyr periods	1-30 days	31-99 days	100-220 days	>220 days	Irr SR	Others
104	28	10	2		3	5		4	
288	1	1				1			
362	15	10	7	2	1				
1261	15	0							
Pal 1	0								
Pal 2	0								
1851	10	0							
1904	7	3	3					1	
2298	2	0							
2419	36	0						5	
2808	9	0							
Pal 3	1	0							
3201	88	84	83						EA, mem?
Pal 4	2	2				2			
4147	16	15	15						
4372	2	0							
4590	42	38	37				1 F		
4833	16	9	6		1		2 F	1	
5024	47	36	33	1	1	1			
5053	11	10	10						
5139	179	159	142	7	5	2	1 F	3	3 E, 1 RRs
5272	212	186	182	1	2	1			1 EW
5286	8	0							
5466	23	21	21						
5634	7	1	1						
5694	0								
14499	129	0							
5824	27	9	9				1		
Pal 5	5	5	5						
5897	7	7	6		1				
5904	97	92	90	2				1	1 UG
5927	11	1					1		
5946	3	0							
5986	5	0							
6093	8	3		1		1 F	1 F		1 N
6101	0								
6121	43	42	40		2				
6139	0								
6144	1	0							
6171	25	23	22				1 F		
6205	11	7	3	3 M	1 M			2 M	1 F
6218	1	1		1					
6229	22	15	14	1					
6235	2	0							

Table I (continued)

NGC	Total variables	Total periods	RR Lyr periods	1-30 days	31-99 days	100-220 days	>220 days	Irr SR	Others
6254	4	2		2				1	
Pal 15	0								
6266	89	74	74						
6273	4	0							
6284	6	0							
6287	3	0							
6293	5	0							
6304	21	0							
6333	13	11	11						
6341	15	13	12						1 EW F
6352	4	0							
6356	10	1				1			
6362	33	15	15						
6366	2	0							
HP 1	15	0							
6380	1	0							
6388	9								
Ton 2	2	0							
6397	3	3	1 F		1 F		1 F		
6401	3	0							
6402	77	40	34	5			1 F		1 N
Pal 6	0								
6426	13	11	11						
6441	10	0							
6453	0								
6496	0								
6522	10	9	8	1 F				1 F	
6528	0								
6535	1	0							
6539	1u	0							
6541	1	0							Slow, prob. mem
6553	18	4	3				1		2 slow, 1 N
6558	9	0							
11276	5	1	1					4?	
6569	5	0							
6584	1	0							
6624	4	0							
6626	18	10	7	2	1				
6637	8	2				2 M			1 RR F, 2 red giant
6638	3	0							
6642	2	0							
6652	0								
6656	32	27	18	1 M	2	2 F?	4 F?	1 M	
6681	2	0							
6712	21	16	10			6			1 UG, 2 E F?
6715	80	37	34	1	1	1			2 E, 2 SR, 3 F

Table I (continued)

NGC	Total variables	Total periods	RR Lyr periods	1-30 days	31-99 days	100-220 days	>220 days	Irr SR	Others
6723	25	19	19						
6752	2	0							
6760	4	0							
6779	12	4	1 F	1	1			6	1 RRs F?
Pal 10	1	0							
6809	6	5	5						
Pal 11	0								
6838	4	2				1		1	1 EA, mem
6864	11	0							
6934	51	30	30						1 slow
6981	40	28	28						
7006	71	58	57		1				
7078	111	68	65	3					
7089	21	21	17	3	1				
7099	12	4	3						1 UG
Pal 12	3	0							
Pal 13	4	4	4						
7492	4	4	3	1					

determined. The next three columns cover the period interval between the RR Lyrae and the Mira stars with periods greater than 220 days. The totals in this period interval are broken down arbitrarily into three groups. The shorter group is made up mainly of W Vir stars, and the longer of short-period Mira stars, with semiregular or RV Tauri types in between. Only those variables technically in the pulsating variable group are included in the above-mentioned columns. Others, mainly eclipsing, are noted in the last column of the table. Mira stars with periods over 220 days are in the eighth column. These are mainly field stars. The ninth column contains those variables with no period given, mainly red ones, with irregular or semiregular fluctuations.

About 8 per cent of the stars in the catalogue, 169 in all, are definitely designated as other than RR Lyrae. There are 39 in the 1-30 day group, 26 in the 31-99, 26 in the 100-219, and 15 with a period of over 220 days. A conspicuous difference between the Third and Second Catalogues is the increase in the number of red irregular variables, many with small ranges.

DISTRIBUTIONS OF RR LYRAE PERIODS

There are 1202 definite RR Lyrae periods known in 46 clusters. The importance of the difference in most frequent length of period in individual clusters has been widely discussed since Oosterhoff first called attention to it. Figure 2 shows the distribution of all RR Lyrae periods in globular clusters for period intervals of 0.01 day. The double maximum of this distribution, conspicuous in the Second Catalogue, is further en-

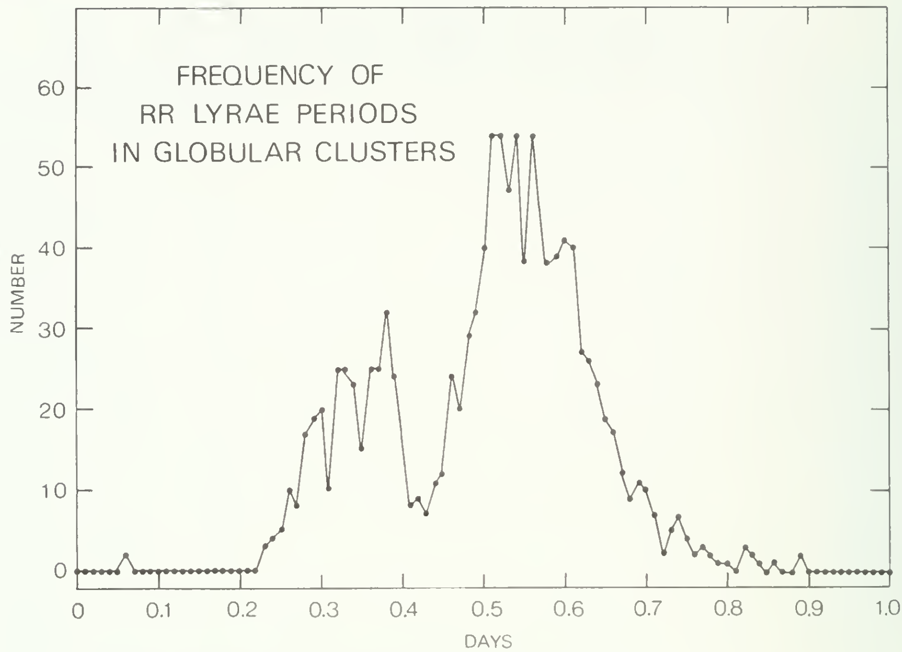

Figure 2 Numbers of RR Lyrae periods at intervals of 0.01 days.

hanced by the new material. Certainly in globular clusters variables of the RR*ab* type have a strong preference for periods around 0.55 day, and of the RR*c* type, around 0.35 day.

DESCRIPTION OF THE CATALOGUE

The catalogue contains every globular cluster considered as belonging to our galaxy for which there is now a published record of search for variables. These clusters number 108, and 11 others are mentioned in brief references.

For the material of the catalogue an attempt has been made to select the most recent or the best determined data. This means that in some clusters for even a single variable the data in different columns may be drawn from different sources. When the Second Catalogue was prepared in 1955, every effort was made to obtain from the authors, or their respective institutions, information sufficient to identify variables listed many years earlier as unpublished. Despite this attempt, much of the unpublished material had to be left in relatively useless form. Now, 17 years later, it seems unlikely that any more of this material can ever be salvaged, and in most cases it is not mentioned in the Third Catalogue.

The system of references has been put on a different basis from that used in the First and Second Catalogues. As the literature proliferates with the years, it becomes no longer feasible to reprint all the references for a cluster in each catalogue. Accordingly

only references since the publication of the Second Catalogue are included for the most part, along with a few overlooked earlier. However, for some clusters on which there has been no key work since then, an occasional early reference has been repeated to aid the reader.

The format of the reference system has also been altered from that used in the earlier catalogues. References are now printed under each cluster. The abbreviations of publications have been chosen to conform to the system of H. Schneller in *Geschichte und Literatur des Lichtwechsels der Veränderlichen Sterne* (Berlin), which seems to convey the necessary information in as concise a manner as possible. An index of the abbreviations used is given at the end of the catalogue. Photo or chart is shown by (p) or (c).

The principal papers on variables in any cluster are listed by author and abbreviated reference. However, there are some papers (23 in all) with remarks about many clusters. These more frequently mentioned papers are abbreviated to initials and the year of publication in this century, the key to these abbreviations being also given at the end, with the title of the paper. For clusters for which the Atlas and Catalogue of Fourcade, Laborde, and Albarracin contains new material, this reference is listed with the main references; otherwise it appears among the highly abbreviated ones.

Anyone actually investigating a cluster is strongly urged to consult the full list of references given in the Second Catalogue.

The clusters are listed in order of NGC number, which does not always correspond to the order in right ascension. Those lacking an NGC number are placed in order of right ascension, which, along with declination, is given for the equinox of 1950. If the cluster has a Messier number, that is given.

The variables are numbered according to the previous catalogues, and new numbers are usually assigned in order of discovery. The policy is to try to restrict the new numbers to those variables within the apparent physical area of the cluster, but it is not feasible to follow this rule rigidly.

The x and y coordinates are given in seconds of arc and correspond in direction to right ascension and declination. For a given cluster, they are usually those published by the first investigator, or reduced to his selected centre. In some cases, these coordinates unfortunately are not yet available.

The magnitudes are usually the latest that have been obtained, which are hopefully the best determined for maximum and minimum. Most of the magnitudes are photographic, but there is a gradual shift to the use of B magnitudes.

The epoch of maximum is usually, but not always, chosen as the one accompanying the period selected. Individual papers should be consulted to determine whether the time is heliocentric or geocentric.

The period is generally that most recently published. Stars with periods less than a day are assumed to be of RR Lyrae type unless otherwise indicated in the remarks. For stars with periods between one and thirty days the type is assumed to be Cepheid.

The "remarks" column contains a miscellany of information. An increase or decrease in period is indicated by + or – respectively, a constant period by "cst" or 0. "Alt" means an alternate period has been published, "var" signifies a variable period, and "Bℓ"

the Blashko effect. An available spectral type is indicated by "Sp" sometimes followed by the type without subdivision, and an available radial velocity by "V." Stars which have been shown to be definitely or very probably field stars are indicated by "f" and proven cluster stars by "mem." The abbreviation used for the type of variable is that in the Third Edition of the *General Catalogue of Variable Stars* by B. V. Kukarkin *et al.* (1969). For variables found since publication of the Second Catalogue, the discoverer is usually indicated.

ACKNOWLEDGMENTS

It is a pleasure to acknowledge the help I have received in the construction of this catalogue. This has come from many astronomers who have sent unpublished or explanatory data, as indicated in the references under individual clusters. I am particularly grateful to Professor Dr. B. V. Kukarkin of Moscow University, who, in the midst of his great task of recording all galactic system variables, has taken time to keep me briefed on Soviet work in globular clusters and to send me corrections to some of my previous papers. Also Dr. H. Wilkens of Argentina has been a constructive reader of my past works, and Dr. Steven van Agt of Nijmegen has straightened out the material on NGC 6362.

My thanks go also to the two directors of this observatory under which the Third Catalogue has been compiled, Dr. John F. Heard and Dr. Donald A. MacRae; to the National Research Council of Canada for their generous support of my cluster program; to my colleagues Dr. Amelia Wehlau of the University of Western Ontario and Dr. Christine Coutts; to the two librarians who assiduously tracked down elusive references, Mrs. Jean Lehmann and Mrs. Sheila Smolkin; to Mrs. Jennie Fabian, who prepared the preliminary version for distribution at IAU Colloquium no. 21 in August 1972; and last but not least to my daughter, Mrs. Sally MacDonald, who searched references and tabulated data.

June 30, 1973
Richmond Hill, Ontario

THIRD CATALOGUE OF VARIABLE STARS IN GLOBULAR CLUSTERS

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 104 (47 Tucanae) $\alpha\ 00^h21^m.9$, $\delta\ -72°21'$							
1	+ 36.8	−112.6	11.60	15.63	35487	212	Sp M, V
2	+ 64.7	−193.9	11.70	14.48	35645	203	Sp M, V
3	+ 328.4	+ 52.8	11.70	15.85	35468	192	Sp M, V
4	− 18.8	−160.4	12.50	14.0	35490	165	
5	+ 271.9	−284.6	13.0	13.7	36158	45	Sp M, V
6	+ 97.3	−103.8	13.0	13.6	36159	47	
7	+ 349.2	−113.0	13.0	13.7	36162	58	Sp M, V
8	+ 16.0	+ 57.0	12.4	14.0	35524	155	Sp M, V
9	− 108	− 78	13.6	14.7	36163.240	0.73652	mem, Sp, V
10	+ 72	+702	13.1	13.6		irr	
11	+ 306	+138	13.2	14.0		irr	
12	+1254	−348	13.89	14.45	36046.614	0.37143	f, Sp, V
13	− 301.95	−139.92					Wilkens
14	+ 8.25	+ 66.83					F&L
15						irr	W300
16							R18
17							W81
18			12.0	12.3			L168
19			11.0	11.6			R10
20			11.7	12.5			A1
21			12.0	13.0			A2
22			11.7	12.2			A4
23			11.7	12.2			A6
24			11.6	11.9			A8
25			11.6	11.9			A9
26			11.8:	12.1:			A13
27			11.9	12.2			A18
28			11.8	12.2			LR5

V15 found by Eggen, 1961; V17 Eggen, 1972; V16 Brooke, 1969. Unpublished V magnitudes given for vars. 18-28, discovered by Lloyd Evans and Menzies, marked on print (1973); their identifying numbers are given in the remarks column. W = Wildey (1961), R = Feast and Thackeray (1960). A field variable, HV 809, is shown by Jones (1973) to be a non-member.

Feast, Thackeray and Wesselink, MN 120.64 (1960); Feast and Thackeray, MN 120.463 (1960); Eggen, Royal Obs Bull 29.E86 (1961); Kurochkin, VS 13.248 (1961); Wildey, ApJ 133.430 (p) (1961); Rosino and Sawyer Hogg, IAU Trans 11B.301 (1962); Arp, Brueckel and Lourens, ApJ 137.228 (1963); Feast, ApJ 137.342 (1963); Tifft, MN 126.210 (1963); Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966); Brooke, Doctoral Thesis, Australian Nat'l Univ (1969); Eggen, ApJ 172.639 (1972); Lloyd Evans, Letter (1972); Jones, IAU Coll 21 (1973); Lloyd Evans and Menzies, IAU Coll 21 (p) (1973)

S55a, S57, S59, S61, A62, R62a, S62, P64, S64, R65, S69, F72

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks

NGC 288 α $00^h50^m.2$, δ −26°52′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	−55	+79	13.5	14.1	25576	103	

Shapley, Star Clusters, p. 45 (1930); Oosterhoff, BAN **9**.397 (1943)
S55a, S59, R62c, S62, S69

NGC 362 α $01^h01^m.6$, δ −71°07′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	−246.2	− 67.6	14.9	16.1	23751.558	0.5850512	
2	+ 41.4	−204.4	13.0	14.5	24391.8	90 var	
3	+ 93.6	−143.2	14.6	16.1	23604.806	0.4744151	
4	− 50.2	− 27.3	14.0	15.8			
5	− 79.2	− 31.9	15.1	16.4	24025.729	0.4900846	
6	+ 82.4	+ 15.5	14.9	16.3	24461.642	0.5146080	
7	+131.1	− 21.2	14.8	16.0	24468.687	0.5285492	
8	+ 33.4	−308.5	15.0	16.5	24433.677	3.901447	
9	−400.4	+224.4	14.7	16.0	24404.670	0.5476126	
10	+282.8	−381.8	14.9	16.4	23315.643	4.20519	
11	−136.1	− 26.0	15.1	16.0			
12	− 30.4	−115.4	15.2	16.1	24391.839	0.65254518	
13	+ 14.5	+ 38.8	14.6	16.3			
14	− 23.8	− 66.8	14.8	16.2			
15	+151.3	−210.7					F&L

Bailey, HA **38**.237 (p) (1902); Sawyer, HC 366 (1931), HC 374 (p) (1932); Kurochkin, VS **13**.248 (1961); Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966); Eggen, ApJ **172**.639 (1972)
S55a, S59, S62, S64, L65, R65, S69

NGC 1261 α $13^h10^m.9$, δ −55°25′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	− 29.8	− 28.4					L&F
2	− 39.8	+ 34.9	16.05	17.25			L&F
3	+ 49.6	− 54.6	15.88	16.67			L&F
4	+ 31.8	− 36.1					L&F
5	− 34.5	− 5.0	16.1	17.0			L&F
6	+ 78.1	− 12.3	16.32	17.32			L&F
7	−149.3	+140.2	16.85	17.3			L&F
8	−133.7	−139.0	16.13	17.48			L&F
9	+ 37.9	− 38.8	16.85	17.15			L&F
10	+ 52.3	+ 70.6	16.17	17.43			L&F
11	− 89.0	+ 89.5	16.85	17.29			L&F
12	+ 87.1	− 10.5	16.35	17.42			Bartolini
13	− 77.1	− 96.0	16.79	17.35			Bartolini
14	− 53.5	− 70.7	16.22	17.23			Bartolini
15	−114.5	+129.1	15.21	15.86			Bartolini

Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966); Laborde and Fourcade, Cordoba Repr 127 (1966); Bartolini, Grilli and Robertson, IBVS 594 (1971); Bartolini, Grilli and Morisi, IBVS 649 (1972); Bartolini, Letter (1972)
S55b, R62b, S67, S69

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks

Palomar 1 α 03^{h}25^m.7, δ +79° 28′

No variables found.
Kinman and Rosino, ASP 74.499 (1962)
R61, S61

Palomar 2 α 04^{h}43^m.1, δ +31° 23′

No variables found.
Rosino and Pinto, IAU Coll 21 (1973)
R61

NGC 1851 α 05^{h}12^m.4, δ −40° 05′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+258.50	− 12.38	14.0	15.5			
2	− 41.25	+ 30.25	14.0	15.5			
3	− 38.50	+ 92.13					
4	+ 24.75	+ 35.75					
5	+ 41.25	+ 41.25					
6	− 74.25	− 8.25					
7	+ 4.13	− 8.35					
8	+ 28.88	+ 24.75	var?				
9	− 57.75	+ 49.50					
10	+ 46.75	−196.63					

Small change in coordinates of vars. 1 and 2 discovered by Bailey. Variable formerly noted as unpublished is considered to be included in above list of new vars. 3-10 discovered by Laborde and Fourcade.

Bailey, HB 802 (1924); Shapley, Star Clusters, p. 45 (1930); Laborde and Fourcade, Cordoba Repr 138 (p) (1966)

S55a, S59, R62c, S62, F&L63, FLA66, S69

NGC 1904 (Messier 79) α 05^{h}22^m.2, δ −24° 34′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+29.6	−199.6	var?				med 16.0
2	+78.3	− 68.3	14.2	14.80		SR	
3	+34.8	− 64.4	15.9	16.7	34032.40	0.73602	
4	+93.4	− 50.1	15.6	16.7	32877.50	0.63492	
5	−11.6	+ 20.2					
6	−70.8	+115.6	16.0	16.6	32940.25	0.33522	
7	+22.5	− 15.2					Tsoo Yu-hua
8	+ 7.1	− 11.7					Tsoo Yu-hua

Pickering, HC 18 (1897); Bailey, HA 38.238 (p) (1902); Rosino, Bologna Pubbl 5, 20 (p) (1952); Tsoo Yu-hua, Letter (p) (1965)

S55a, S59, S62, L65, R65, S67, S69

No.	x"	y"	Max.	Min.	Epoch	Period	Remarks
NGC 2298 α $06^h47^m.2$, δ $-35°57'$							
1	+119.35	−37.40					F&L
2	− 30.53	−22.28					F&L

Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966)
S55a, S59, R62c, S62, F&L63, S69

No.	x"	y"	Max.	Min.	Epoch	Period	Remarks
NGC 2419 α $07^h34^m.8$, δ $+39°00'$							
1	+ 40	− 52	17.59	18.32		irr	
2	− 4	− 19					
3	+ 52	− 24	18.66	19.96			
4	+ 80	− 15	18.84	19.65			
5	+ 33	+ 47	18.75	19.72			
6	+ 56	−127	18.86	19.64			
7	+ 91	+ 87	18.69	19.77			
8	− 17	+ 41	17.50	18.10		irr	
9	− 32	+ 88	18.59	19.76			
10	+ 20	− 51	17.31	17.93		irr	
11	+ 95	− 8	18.55	19.81			
12	+133	+111	18.69	19.71			
13	+101	− 10	18.55	19.75			
14	−115	− 13	18.81	19.62			
15	+ 62	+ 40	18.62	19.76			
16	+ 47	+ 72	18.77	19.85			
17	+109	+111	18.65	19.75			
18	− 15	+114	17.84	18.53		irr	
19	−107	− 40	18.77	19.86			
20	− 28	+ 45	17.65	18.16		irr	
21	− 55	+ 30	18.76	19.74			
22	+109	− 5	18.60	19.84			
23	+ 27	+ 79					
24	−147	− 10	18.94	19.58			
25	− 59	+ 38	18.78	19.70			
26	− 70	− 50					
27	+ 19	−103	19.10	19.55			
28	−192	+ 59	18.72	19.78			
29	− 58	− 7	19.01	19.92			
30	− 26	+ 23					
31	+154	−146	19.08	19.53			
32	− 19	+ 48	18.60	19.71			
33	+ 47	− 17	19.11	20.13			
34	+ 21	+157	19.00	19.66			
35	+ 43	+ 8	18.88	20.00			
36	+ 23	+ 44	19.10	19.83			

Kinman has two RR Lyrae periods, 0.37 and 0.63 days.
Baade, ApJ 82.396 (p) (1935); Rosino and Sawyer Hogg, IAU Trans 11B.301 (1962)
S55a, S59, S62, R65, S69

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks

NGC 2808 α 09^{h}10^{m}.9, δ-64° 39′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+107.25	− 35.20					F&L
2	− 48.13	+ 34.10					F&L
3	+ 31.63	− 61.33					F&L
4	−191.13	+ 60.50					F&L
5	+ 39.05	− 66.00					F&L
6	+168.58	−291.50					F&L
7	+ 63.25	+ 60.50					F&L
8			14.87	15.92			Alcaino 27
9			15.68	16.96			Alcaino 35

Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966); Alcaino, Astr and Ap 15.360 (p) (1971)
S55a, S59, R62c, S62, S69

Palomar 3 α 10^{h}03^{m}.0, δ+00° 18′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
V1 on print						prob RR	B&S

Burbidge and Sandage, ApJ 127.527 (p) (1958)
S61, S62, S69

NGC 3201 α 10^{h}15^{m}.5, δ −46° 09′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+ 59	− 118	14.56	15.66	39505.858	0.6048761	+
2	+ 29	− 117	14.61	15.60	28272.352	0.5326722	
3	+ 182	− 43	14.84	15.52	39504.76:	0.5994093	−
4	+ 155	+ 3	14.76	15.60	23198.539	0.6300006	
5	+ 42	− 24	14.40	15.54	39504.853	0.5015359	+
6	− 116	− 143	14.42	15.42	39506.796	0.5256131	−
7	− 91	− 189	14.88	15.40	39505.823	0.6303322	+
8	− 69	− 99	15.06	15.40	39504.816	0.6286280	+
9	− 51	− 91	14.86	15.57	23506.605	0.5266970	
10	− 181	+ 235	14.66	15.59	22429.597	0.5351571	
11	− 104	+ 112	14.82	15.36	39506.804	0.2990471	+
12	− 86	+ 108	14.50	15.53	23547.577	0.4955583	
13	− 160	+ 92	14.66	15.56	39506.720	0.5752145	+
14	− 156	+ 133	14.61	15.67	23961.495	0.5092897	
15	− 279	− 173	14.34	15.43	23164.572	0.5346644	
16	− 197	− 238	14.83	15.21	39504.819	0.365	
17	+ 11	− 25	14.80	15.52	39506.874	0.5655773	−
18	+ 23	− 24	14.73	15.54	39504.872	0.53	
19	+ 23	+ 317	14.40	15.50	39506.821	0.5250201	−
20	+ 39	+ 284	14.40	15.52	39505.816	0.5291064	+
21	+ 94	+ 135	14.74	15.62	39506.763	0.5666509	+
22	− 100	− 56	14.66	15.57	39506.825	0.6059842	+
23	− 49	− 50	14.75:	15.12:	39504.81	0.61	Companion
24	− 339	+ 17	14.40	15.52	39505.869	0.5889798	−
25	+ 93	+ 173	14.43	15.47	39505.818	0.5147963	+

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 3201 (continued)							
26	+ 219	− 140	14.87	15.70	39505.878	0.5689949	−
27	+ 58	− 323	14.08	15.32	39505.790	0.4842943	+
28	+ 66	− 48	14.70	15.60	39505.760	0.5786766	−
29	− 256	+ 113	15.12	15.48	39506.74:	0.343	
30	− 289	+ 272	14.29	15.49	39504.814	0.5158559	+
31	+ 182	+ 131	14.65	15.51	23505.620	0.5194894	
32	+ 195	+ 199	14.30	15.54	39504.900	0.5611656	+
33	+ 48	− 40	not var				
34	+ 296	+ 285	14.37	15.62	23547.577	0.4678883	
35	− 11	+ 121	14.90	15.45	22484.504	0.6155244	
36	− 108	− 11	14.68	15.2:	39505.794	0.242	Alt 0.323
37	− 68	− 74	15.04	15.40	39504.77	0.273	Alt 0.382
38	− 61	− 60	14.70	15.60	23877.612	0.5091616	
39	+ 41	+ 54	14.83	15.80	23181.537	0.4832092	
40	− 96	+ 68	15.10	15.56:	39504.90	0.642	Alt 0.385
41	+ 291	+ 28		15.55		0.66	
42	− 301	+ 197	14.26	15.40	39504.840	0.5382490	+
43	− 377	+ 15	14.80	15.39	23166.665	0.6761289	
44	+ 31	+ 67	15.01	15.66	23190.635	0.6107344	
45	+ 127	− 32	14.56	15.60	39505.859	0.5374165	+
46	− 396	− 510	14.56	15.35	23167.570	0.5431990	
47	+ 108	+ 245	14.78	15.42	39504.903	0.342:	Bℓ, Alt 0.51
48	− 252	+ 12	14.96:	15.36	39506.67:	0.336	Alt 0.252
49	− 38	+ 151	14.72:	15.46	39504.76:	0.5814870	+
50	− 13	+ 27	14.80	15.72	39506.88	0.565	
51	− 205	− 26	14.50	15.30	39506.813	0.5205454	+
52	+ 14	− 812	14.90	15.30	39505.78:	0.38:	
53	− 873	− 758	14.57	15.38	23191.540	0.5334705	
54	+ 671	− 804	14.71	15.8:	39506.776	0.5558721	+
55	− 338	+ 767	14.47	15.43	39504.915	0.607	
56	+ 246	+ 94	14.95	15.62	23164.591	0.5903376	
57	+ 288	− 72	14.74	15.58	39506.762	0.5934373	+
58	+ 346	− 80	14.94	15.45	23164.538	0.6220418	
59	− 490	− 70	14.28	15.28	39506.813	0.5177106	+
60	− 850	+ 95	14.08	15.38	39505.798	0.5035723	−
61	−1125	+ 175	14.12	15.59	39504.91	0.54	
62	−1060	− 186	14.29	15.49	39505.798	0.5697558	−
63	−1000	+ 59	14.36	15.39	23914.582	0.5680998	
64	− 646	+ 863	14.32	15.54	39504.815	0.5224218	+
65	− 544	+ 797	14.01	15.03	39506.71	1.660024	EA, Min, mem?
66	− 398	+ 289	14.90	15.27	39506.78	0.284	
67	− 374	− 120	14.75:	15.31	39506.70:	0.329	Alt 0.494
68	− 283	+ 846				long	
69	− 221	+ 995	14.34	15.50	23914.575	0.5122704	
70	− 221	− 13	not var				
71	− 182	− 117	14.35	15.39	39506.765	0.6011859	+
72	− 161	+ 596	15.00	15.24		0.36?	

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 3201 (continued)							
73	− 128	+ 86	14.40	15.60	39504.860	0.5199500	+
74	− 94	+ 36	not var				
75	− 81	+ 147	not var				
76	− 62	− 42	15.16	15.72	39506.74	0.343	Alt 0.52
77	− 10	− 52	14.64	15.50	22429.592	0.5676648	−
78	− 8	− 143	14.48	15.48	39504.83	0.514	
79	+ 10	− 101	not var				
80	+ 60	+ 23	14.82	15.60	39505.79	0.58	
81	+ 96	− 153					
82	+ 161	− 166	not var				
83	+ 177	+ 172	14.44	15.62	23190.624	0.5451918	−
84	+ 358	+ 703	14.65	15.43	22077.566	0.5136787	
85	+ 569	− 403	not var				
86	+ 611	− 315	not var				
87	+1013	− 460	14.65	15.30	23164.633	0.6038866	
88	+ 234	+1086	14.48	15.61	39504.86	0.57	Wilkens 1
89	+1404	− 180	14.90	15.38	39505.83	0.369	Wilkens 2
90	− 24	+ 06	14.8:	15.65	39504.73:	0.61	Wilkens 3
91	−1524	+1170	14.64	15.10	39504.98	0.345	Wilkens 4
92	− 150	− 30	14.48	15.50	39506.80	0.523	Wilkens 5
93	+1986	− 192				0.48?	Wilkens 6
94	−2862	+1824				RR	Wilkens 7
95	+1860	+2580				RR	Wilkens 8
96	−2790	− 468	14.50	15.50	39506.86	0.59	Wilkens 9

Wilkens no. 10 = V39. Kukarkin considers Wilkens' new variables are cluster members, forming a large corona, and says identifications of vars. 6, 11, 45, 52, 57, 68 and 81 are erroneous in FLA66.

Wilkens, MVS 3.75 (1965); Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966); Kukarkin, AC 426.4 (1967), AC 428.1 (1967), AC 637.4 (1971), VS 17.610 (1971), Letter (1971)

S55a, S57, S59, S61, R62a, S62, S64, L65, R65, St66, S67, S69, S70

Palomar 4 $\alpha\ 11^h26^m.6$, $\delta\ +29°\ 15'$

1	−12	−4	17.7	20	35922	130.50	Rosino
2	−43	−3	17.6	19.3	35938	109.30	Rosino

Rosino, Asiago Contr 85 (1957); Burbidge and Sandage, ApJ 127.527 (1958); Rosino and Pinto, IAU Coll 21 (1973)

R57, S59, R61, S61, S62, S69

NGC 4147 $\alpha\ 12^h07^m.6$, $\delta\ +18°49'$

1	−100.1	− 45.7	16.36	17.76	35546.544	0.5003860	
2	− 20.2	− 28.8	16.46	17.64	35538.485	0.49306	
3	− 28.5	− 35.3	16.68	17.24	35538.591	0.280542	
4	+ 1	+ 18	16.27	17.29	34805.859	0.30097	
5	+ 14.9	+ 2.7	17.0	17.4		0.34125:	Newburn
6	+ 31.2	+ 28.4	16.29	17.67	34805.675	0.61860	S&W

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 4147 (continued)							
7	+ 4.6	+ 7.4	16.4	17.6	34805.924	0.51294	S&W
8	+ 8.6	+ 2.3	16.9	17.5		0.3897:	S&W
9			prob not var				S&W print
10	− 47.8	− 45.6	16.96	17.54	35538.528	0.352314	S&W
11	− 12.2	− 41.9	16.72	17.30	35538.670	0.38739	S&W
12	+ 5.1	− 4.2	16.6	17.6		0.5:	S&W
13	+ 0.1	− 19.0	16.8	17.3		0.3759:	S&W
14	+ 8.4	− 0.2	16.9	17.5		0.5255:	Newburn
15	+ 9.2	− 7.8	16.8	17.3		0.3354:	Newburn
16	+ 14.5	+ 7.7	16.8	17.1		0.2775:	Newburn
17	+ 63.7	+143.3	16.72	17.34	35538.430	0.37473	Newburn

Five field variables, Baade.

Baade, AN **244**.153 (1931); Sandage and Walker, AJ 60.230 (p) (1955); Newburn, AJ 62.197 (1957); Mannino, Asiago Contr 87 (1958)

S55a, S57, S59, S61, R62a, S62, L65, R65, S69

NGC 4372 $\alpha\ 12^h23^m.0,\ \delta -72°24'$

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	−739.75	− 42.08					F&L
2	+612.15	−382.25					F&L

Wilkens, Letter (1961); Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966)
S55a, S57, S59, S61, R62c, S62, F&L63, S69

NGC 4590 (Messier 68) $\alpha\ 12^h36^m.8,\ \delta -26°29'$

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	−283	+109	15.55	16.11	33421.357	0.349604	
2	−168	− 44	15.05	16.29	33661.66	0.578169	
3	−140	+ 91	15.40	16.15	33661.66	0.4158	
4	−118	−132	15.65	16.20	33423.273	0.396367	
5	− 53	+169	15.47	16.11	33423.297	0.282116	
6	− 54	+ 17	15.75	16.07	33422.413	0.368523	
7	− 51	− 78	15.71	16.07	33423.478	0.387945	
8	− 35	−134	15.74	16.13	33422.359	0.390402	
9	− 30	+ 40	15.43	16.28	33422.257	0.57900	
10	− 24	− 14	15.28	16.62	33423.224	0.55112	
11	− 17	−113	15.65	16.16	33423.295	0.36489	
12	− 12	00	15.07	16.23	33423.333	0.6162	
13	− 4	− 57	15.72	16.11	33423.385	0.361740	
14	− 2	+218	15.02	16.25	33421.437	0.55679	
15	+ 10	+ 59	15.65	16.36	33423.360	0.37220	
16	+ 10	+ 78	15.65	16.22	33423.289	0.381967	
17	+ 17	− 74	15.65	16.60	33418.293	0.66693	
18	+ 18	− 96	15.69	16.19	33423.327	0.367346	
19	+ 32	+ 70	15.65	16.20	33421.404	0.39206	
20	+ 33	−114	15.69	16.14	33421.293	0.385764	
21	+ 46	+ 8	15.82	16.60	33423.358	0.37241	
22	+ 61	− 22	15.30	16.52	33421.424	0.563469	
23	+ 65	+380	14.85	16.13	33423.198	0.6588799	

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 4590 (continued)							
24	+ 72	− 8	15.64	16.13	33422.268	0.376500	
25	+140	+123	15.00	16.15	33423.328	0.641556	
26	+157	− 45	15.63	16.11	33799.370	0.413217	
27	+381	+263	10.2	17.4	33661.	320	Fl Hya, f
28	+439	+159	14.81	16.18	33423.292	0.6067750	
29	+283	−153	15.65	16.15	33419.416	0.395253	
30	+112	− 77	15.60	16.20	33422.442	0.73362	
31	−109	+ 96	15.49	16.10	33423.310	0.399658	
32	−330	−639			33422.362	0.58692	van Agt
33	+ 89	+ 59			33422.317	0.38523	van Agt
34	+268	+216			33422.314	0.39696	van Agt
35	− 35	− 52			33421.340	0.71608	van Agt
36	− 38	− 52			33422.374	0.6998	van Agt
37	− 21	+ 20			33423.317	0.38553	van Agt
38	− 22	− 29			33423.251	0.3826	van Agt
39	− 50	− 8					T,R&O
40	− 1	− 52					T,R&O
41	+ 4	+ 80					T,R&O
42	− 3	+ 37					T,R&O

Five new field variables, Terzan et al. (1973)

Rosino and Pietra, Bologna Pubbl **6**, 5 (1954); van Agt and Oosterhoff, Leiden Ann 21.253 (p) (1959); Terzan, Rutily and Ounnas, IAU Coll 21 (p) (1973)

S55a, S57, S59, S61, R62a, L65, R65, S69

NGC 4833 α 12^{h}56^m.0, δ −70° 36′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	−264	+468	15.32	15.86	29375.251	0.750101	RY Mus
2	+378	−354	13.0	16.2:	26166	333.7	RZ Mus, V, f
3	0	+ 6	15.46	15.9	29363.248	0.744526	
4	0	+ 24	15.24	15.88	29381.249	0.655536	
5	+132	− 66	15.4	16.0	29381.240	0.629414	
6	+120	+120	15.3	15.9	29381.297	0.653967	
7	+ 72	− 6	15.49	16.05:	29374.256	0.668422	
8	−168	+498	15.59	15.79			
9	− 42	− 6	14.5	15.16	28035	87.7:	
10	+ 72	+414	15.14	15.9			
11	−336	−828	14.5	16.0:	24320	303.8	
12	+ 19.2	+ 13.7					F&L, RR?
13	+272.2	− 30.2					F&L, RR?
14	− 13.7	− 38.5					F&L, RR?
15	− 15.1	− 57.7					F&L, RR?
16	− 76.5	+151.2				irr	F&L, red

Menzies confirms variability of all these stars, with small variation for V16. He lists eight new suspected variables, Menzies B57, B84, B105, B121, B193, C80, C308 (all appear to be RR Lyr), and D199 (perhaps Pop II Cepheid), identified on print.

Feast, Obs **86**.120 (1966); Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966); Menzies, MN **156**.207 (p) (1972)

S55a, S59, R62a, S62, L65, R65, S67, S69

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 5024 (Messier 53) $\alpha 13^h 10^m.5$, δ +18° 26′							
1	+ 9.6	−171.0	15.75	17.20	23083.408	0.6098240	+
2	− 78.0	−183.6	16.30	16.90	22787.498	0.3861005	
3	− 60.6	−138.0	16.10	17.10	23113.388	0.6306134	0
4	−169.5	−156.6	16.41	16.84	23113.482	0.3851900	+
5	−237.0	−258.0	15.75	17.10	23143.336	0.6394247	−
6	+123.6	+ 13.5	16.00	17.20	23083.457	0.66401573	−
7	+ 79.5	+ 83.5	15.85	17.15	23145.418	0.5448396	+
8	+ 72.0	+ 60.0	16.10	17.10	22762.553	0.61553333	−
9	+ 67.5	− 40.5	15.90	17.10	23145.523	0.6003694	−
10	−138.6	+ 54.0	15.85	17.05	23143.446	0.6082562	0
11	−143.4	− 58.5	15.85	17.0	23113.525	0.6299592	+
12	+409.5	+187.5	15.90	17.15	23113.579	0.61258094	−
13	+462.0	−299.7	15.75	17.10	23143.419	0.6274424	−
14	+354.6	−207.0	15.80	17.10	23143.363	0.5454029	−
15	+248.4	+228.0	16.39	16.67	23113.361	0.3087107	+
16	−136.5	−202.5	16.43	16.90	23113.402	0.3031728	
17	−214.5	+114.0	16.29	16.80	22762.612	0.3814992	
18	− 96.0	+ 12.6	15.83	16.42			
19	+165.6	− 42.0	16.34	16.85	22789.465	0.3918418	
20	+188.4	−351.6	16.32	16.81	23113.615	0.3844212	−
21	+437.4	− 27.0	16.32	16.81	22790.410	0.3384650	
22	− 53.4	−288.0	16.56	16.85	var?		
23	+ 96.0	− 89.7	16.34	16.88	23113.460	0.3658077	
24	−118.5	− 29.2	15.71	16.43		3.?	
25	+130.3	+ 31.7	16.05	17.0	23113.392	0.70516256	−
26	−288.0	−279.9	16.20	16.85	23113.343	0.3911166	
27	−203.8	−157.9	16.0	17.10	23083.620	0.6710599	0
28	−181.4	+459.0	15.65	17.05	23113.183	0.63279704	+
29	+125.4	− 79.5	16.56	17.04	22808.305	0.8232463	+
30	+ 57.7	−482.8	15.6	17.6	31223.384	0.53548466	B♀, 37^d
31	+ 60.6	− 0.1					
32	−111.9	− 86.6	16.26	16.65	22790.475	0.3901324	
33	−165.0	+ 12.2					
34	−144.0	−216.7	16.48	16.70	not var		
35	+104.1	+153.2	16.25	16.95	23113.327	0.3726739	0
36	+120.3	+306.5	16.33	16.71	23113.698	0.3732511	
37	− 44.0	+ 62.2	15.68	16.48			
38	+ 21.3	−143.2	16.0	17.0	23083.773	0.7057873	+
39	−234.0	+212.5	16.84	17.26	not var		
40	+ 8.9	+111.5					
41	+ 19	+ 66					
42	− 67	+ 17	15.54	16.33			
43	− 34	+ 53					
44	+ 53	− 2	15.20	15.99			
45	− 5	− 36					
46	− 12	+ 34					
47	− 68.7	+138.0	16.20	16.80	37763.435	0.35051	Margoni

NGC 5024 (continued)

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
48	+ 4.68	+ 11.58	16.63	17.53	34480.91	0.3327660	Cuffey 47
49	+ 1.05	+ 4.39	15.25	15.65	34478.5	111.6	Cuffey 48
50	− 2.28	− 1.34	15.22	15.52	34482.0	55.4	Cuffey 49

Cuffey, AJ 67.574 (1962); Margoni, Asiago Contr 150 (1964); Cuffey, AJ 70.732 (1965); Margoni, Asiago Contr 170 (1965), Bamb Kl Veröff 4.40.249 (1965); Wachmann, Astr Abh Hoffmeister p. 121 (1965); Cuffey, AJ 71.514 (1966); Margoni, Asiago Contr 198 (1967); Wachmann, Berg Abh 8.114 (1968)

S55a, S57, S59, S61, R62a, S62, S64, L65, R65, S67, C&S69, S69, S70

NGC 5053 α 13^{h}13^m.9, δ +17°57′

1	−380	+158	15.8	16.5	37343.456	0.6471748	
2	−193	− 3	15.9	16.6	37370.575	0.3789561	+
3	+140	+138	15.8	16.6	37370.470	0.5929430	
4	+ 31	−114	15.8	16.5	37371.454	0.6670627	
5	+220	−220	16.0	16.6	37370.641	0.7148605	
6	+126	+ 77	16.0	16.5	37370.556	0.2921978	
7	− 87	+169	15.9	16.5	37370.469	0.3519300	+
8	+117	+ 50	15.9	16.5	37371.452	0.3628410	−
9	−199	+382	16.0	16.6	37371.407	0.7402201	
10	+ 94	+ 56	16.10	16.45	37370.427	0.4373803	Alt P?
11			16.01	16.47			Perova

Perova's var., V11, is Baade's comparison star c.

Perova, VS 14.255 (1962); Mannino, Bologna Pubbl 8, 12 (1963)

S55a, S59, R62a, S62, S64, L65, R65, C&S69, S69

NGC 5139 (ω Centauri) α 13^{h}23^m.8, δ −47° 13′

1	− 416.16	+298.89	11.05	12.45	30027.0	29.3479*	0, Sp, F, V, mem
2	− 340.00	+238.51	]13.06	16.12	30139.4	235.74	0, f
3	− 507.93	+167.43	14.11	15.14	27000.42	0.8412403	−
4	− 337.61	+262.10	14.96	15.25	27000.32	0.6273172	+
5	− 282.75	+328.29	14.48	15.49	27000.44	0.5152823	+
6	− 162.43	+252.95	13.84	15.24	27010.1	73.513	0, prob f
7	+ 153.19	+879.15	14.15	15.33	27000.20	0.7130181	+
8	+ 629.43	+ 16.20	14.03	15.35	27000.31	0.5212859	+
9	− 473.17	+137.14	14.31	15.28	30000.04	0.5233301	0
10	− 397.76	+244.48	14.43	14.95	27000.06	0.374956	−
11	− 158.63	+338.73	13.90	15.04	27000.19	0.5648246	−
12	− 193.16	+274.34	14.43	14.95	27000.08	0.3867639	0
13	− 487.26	+199.54	13.96	15.14	30000.50	0.6690507	0
14	− 473.51	−627.56	14.56	15.17	30000.29	0.3771102	0
15	− 194.09	+242.62	13.70	14.39	27000.40	0.8106152	+
16	+ 517.05	−536.81	14.46	15.04	27000.07	0.3301802	+
17	+ 522.24	+200.00	14.18	14.61	30062.2	64.725	irr, prob f
18	+ 596.64	+220.15	14.06	15.35	30000.42	0.6216671	0

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 5139 (continued)							
19	+ 444.14	+ 32.44	14.76	15.30	30000.11	0.2995525	0
20	+ 280.88	+ 32.06	14.09	15.28	27000.61	0.6155528	+
21	− 355.75	+162.07	14.20	14.81	30000.10	0.380810	
22	+ 552.18	−330.22	14.63	15.17	27000.22	0.3965212	
23	+ 2.54	+240.71	14.26	15.39	27000.17	0.5108653	+
24	+ 524.71	−336.96	14.57	15.04	27000.08	0.4622076	+
25	− 210.77	+ 17.48	13.98	15.07	30000.50	0.5885146	0
26	− 229.58	+101.21	14.36	15.06	27000.15	0.7847138	+
27	− 205.47	+ 24.11	14.50	15.19	30000.02	0.6157067	0
28			not var				
29	− 193.25	− 6.45	12.39	13.50	30008.98	14.73383	0, Cep, mem
30	− 307.92	− 75.01			30000.21	0.403988	0
31			not var				
32	+ 174.39	+420.01	13.87	15.20	27000.39	0.6204298	−
33	− 554.54	− 24.00	14.16:	15.25:	27000.52	0.6023334	−
34	− 396.87	−269.04	14.10:	15.00::	27000.55	0.7339428	+
35	+ 71.70	+365.07	14.43	15.00	27000.00	0.3868382	−
36	+ 246.11	+789.42	14.62	15.17	30000.26	0.379846	0
37			not var				
38	+ 169.10	−470.37	14.45	15.20	27000.01	0.7790474	+
39	+ 741.86	−365.80	14.48	15.08	30000.21	0.3933505	0
40	− 220.99	−125.30	13.95	15.15	30000.11	0.6340925	0
41	+ 151.80	−142.18	14.03	15.06	27000.53	0.6629590	+
42	+ 0.21	− 50.21	12.5	14.9		149.4	
43	+ 119.23	+103.16	13.27	14.29	30000.65	1.156706	0, Cep, mem
44	− 243.40	−354.05	13.67:	14.65:	30000.48	0.5675440	0
45	− 764.48	+ 80.97	14.18	15.37	27000.09	0.5891301	+
46	− 770.61	+170.11	14.43	15.44	27000.60	0.6869406	+
47	− 504.32	+269.26	14.07	14.60	27000.15	0.4851319	−
48	− 86.54	−104.54	12.95	13.80	30003.6	4.47227	0, Cep, mem
49	− 391.98	−553.77	14.40	15.52	30000.36	0.6046505	0
50	− 530.75	+ 65.40	14.32	14.90	30000.20	0.3861960	0
51	− 36.85	+258.73	13.86	15.16	27000.08	0.5741332	+
52	− 112.85	+ 36.47	13.60	14.22	30000.28	0.6603703	0
53	− 482.79	−447.74	13.30	13.87		32.7	irr, Alt 70
54	− 229.39	+592.76	14.33	15.22	27000.30	0.7728973	+
55	− 617.73	−816.68	14.50	15.50	27000.11	0.5817244	−
56	− 515.93	−541.96	14.56	15.57	27000.42	0.5680098	−
57	+ 635.72	−493.26	14.52	15.16	27000.44	0.7944181	+
58	− 335.44	+277.68	14.49	14.74	30000.28	0.3699124	0
59	− 282.90	− 65.84	14.20	15.18	30000.41	0.5185122	0
60	− 108.42	−247.33	13.24	14.47	30001.00	1.349464	0, Cep, mem
61	+ 280.44	+ 68.07	13.65	14.42	30001.59	2.273564	0, Cep, mem
62	− 199.80	+ 45.28	13.88	15.10	27000.31	0.6197945	+
63	− 996.82	−491.46	14.59	15.17	27000.24	0.8259432	+
64	− 448.01	−457.49	14.54	15.14	30000.24	0.344621	+
65	− 454.49	−474.32	14.72:	15.17:	30000.022	0.06272267	0, f, RRs

No.	x"	y"	Max.	Min.	Epoch	Period	Remarks
NGC 5139 (continued)							
66	− 133.37	+375.15	14.46	14.95	27000.24	0.4074[illegible]	+
67	− 178.11	+593.57	14.18	15.28	27000.41	0.5644510	+
68	− 338.18	+545.12	14.15	14.67	30000.1	0.534708	0
69	− 965.76	+530.94	14.14	15.35	27000.24	0.6532208	+
70	+ 417.83	−304.65	14.62	15.11	30000.2	0.390596	0
71	+ 220.39	+ 47.13	14.38	14.92	30000.2	0.3574826	0
72	+ 477.85	+734.87	14.44	15.10	27000.17	0.3845221	+
73	− 532.49	+750.76	14.00	15.32	27000.42	0.5752151	+
74	+ 215.47	+664.83	14.10:	15.29:	27000.43	0.5032480	+
75	+ 341.44	+591.55	14.52	15.07	30000.16	0.4283681	0
76	+ 113.31	+511.81	14.21:	14.72:	27000.17	0.3378487	+
77	+ 352.29	+392.42	14.39	14.85	30000.10	0.4260045	0
78	+ 586.10	+146.68	14.17	14.84	33929.972	1.16812901	−, EA, Min, mem
79	+1000.12	− 51.02	14.26	15.39	27000.23	0.6082758	+
80	+1304:	108:	14.1:	14.8		0.45	Alt 0.31
81	+ 511.36	+228.72	14.39	14.93	27000.14	0.3894005	+
82	+ 499.94	+126.98	14.47	15.00	30000.12	0.335931	0
83	+ 226.09	+424.66	14.50	15.07	27000.29	0.3566071	+
84	−1202.81	− 74.70	14.37:	15.10:	30000.33	0.5798732	0
85	−1010.51	+307.98	14.33	15.13:	27000.10	0.7427583	+
86	+ 293.14	+147.26	13.96	15.18	27000.32	0.6478337	+
87	+ 113.68	+184.13	14.40	14.90	30000.04	0.3965978	0
88	+ 98.13	+203.28	14.01	14.81	27000.22	0.6901959	+
89	− 2.95	+159.29	14.47	14.97	30000.29	0.374948	0
90	− 5.30	+137.09	13.81	14.73	27000.48	0.6034020	+
91	+ 43.72	+144.35	14.25	14.91	27000.18	0.8951197	
92	− 317.86	+446.38	14.10:	14.68:	30000.00	1.345044	0, Cep, mem
93			not var				
94	− 504.09	+355.09	14.58:	14.99:	30000.20	0.2539334	0
95	− 824.80	− 11.05	14.51	15.02	27000.39	0.4050201	+
96	− 71.20	+ 97.06	13.93	14.82	27000.08	0.6245320	+
97	+ 225.50	+187.93	14.11	15.16	27000.65	0.6918907	+
98	+ 198.25	+102.38	14.57	15.09	30000.19	0.2805649	0
99	+ 160.35	+ 50.36	13.77	14.90	37000.59	0.766140	+
100	+ 179.49	+ 65.68	14.05	15.05	27000.48	0.5527119	+
101	+ 444.11	− 73.28	14.46	14.90	26523.291	0.3408843	
102	+ 361.83	− 94.10	14.16	15.22	27000.13	0.6913899	+
103	+ 283.14	+ 2.35	14.46	14.80	30000.02	0.3288489	0
104	+ 822.98	−309.01	14.52	14.94	37000.51	0.867280	−
105	+ 603.23	−246.92	14.70	15.25	27000.14	0.3353345	+
106	+ 130.35	+ 26.92	13.88	15.02	27000.22	0.5699061	−
107	+ 279.83	−139.13	14.07	15.39	27000.07	0.5141002	+
108	+ 185.66	− 46.36	13.84	14.81	27000.24	0.5944554	+
109	+ 153.91	− 57.13	13.99	15.03	27000.67	0.7440615	[illegible]
110	+ 158.94	− 87.08	14.41	14.96	26524.256	0.322102[illegible]	
111	+ 27.26	− 0.30	14.18	14.80	27000.02	0.7629005	+
112	+ 79.83	−103.36	13.92	14.92	30000.07	0.4743558	0

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 5139 (continued)							
113	+ 99.99	−187.65	13.94	15.22	27000.39	0.5733636	+
114	+ 38.08	−101.15	14.00	14.75	26470.416	0.6753065	
115	− 345.49	−336.14	14.12	15.30	27000.14	0.6304638	−
116	− 109.66	+ 33.71	14.12	14.77	30000.37	0.7201327	0
117	− 267.73	− 40.22	14.40	14.92	30000.17	0.4216616	0
118	− 58.87	− 98.67	13.88	15.02	30000.03	0.6116283	0
119	− 82.04	−157.45	14.51	14.83	26472.319	0.3058774	
120	− 211.29	−247.61	14.26	15.23	27000.51	0.5485746	−
121	− 184.36	−189.58	14.48	14.81	27000.00	0.3041811	+
122	− 162.92	−261.41	13.99	15.17	27000.06	0.6349267	+
123	+ 46.11	−512.55	14.42	14.91	26473.331	0.4739051	
124	+ 78.88	−626.81	14.37	14.97	30000.02	0.3318607	0
125	+ 23.74	−742.59	14.04	15.33	27000.26	0.5928884	+
126	+ 822.95	−730.44	14.45	14.97	30000.17	0.3418905	0
127	− 880.16	+ 4.31	14.60	15.12	30000.03	0.3052736	0
128	− 289.77	− 92.09	14.25	14.86	27000.43	0.8349478	+
129	+ 192.02	− 25.83	14.18	14.74			f
130	− 366.17	+900.99	14.13	15.49	30000.38	0.4932499	0
131	− 165.05	− 59.95	14.40	14.86	27000.19	0.3921558	−
132	− 72.44	− 29.31	13.97	14.96	26469.386	0.6556410	
133	−1914.22	+1053.78	13.74	14.53	30000.07	0.31709593	0, EW, Min
134	− 942.87	+ 972.72	14.12	15.32	30000.57	0.6529026	0
135	− 184.88	− 37.25	13.87	14.85	26470.314	0.6325795	
136	− 154.26	+ 60.08	14.22	14.64	30000.0	0.3919136	0
137	− 149.54	+ 96.23	14.38	14.90	30000.29	0.3342179	0
138	− 111.12	− 187.55	12.5	13.6		74.6: irr.	
139	− 86.94	+ 65.18	14.00	14.90	26462.404	0.6768666	
140	− 42.65	− 86.80				short	
141	− 55.47	− 47.46	14.05	14.75	irr	0.6975651	
142	− 37.35	− 2.56	14.2	14.8		short	
143	− 37.45	+ 71.40	14.24	14.77	26470.394	0.8207020	
144	− 33.28	+ 22.44	14.33	14.81	26454.329	0.8353054	
145	+ 49.07	− 148.51	14.40	14.87	30000.15	0.373139	0
146	+ 65.96	− 48.03	13.87	14.77	26469.386	0.6331021	
147	+ 298.70	− 151.04	14.35	14.80	30000.34	0.4226989	0
148	+ 299.20	+ 44.21	12.9	13.8		90: irr.	
149	+ 477.33	+ 894.18	14.03	15.11	30000.42	0.6827281	0
150	+ 543.18	− 442.23	14.07	14.94	30000.7	0.8991997	0
151	+1010.06	+ 753.35	14.42	14.84	30000.1	0.4077838	0
152	+ 13.84	− 48.83	12.8	13.7		124:	irr
153	+ 34.46	+ 136.32	14.48	14.88	30000.23	0.386445	0
154	+ 169.59	− 113.20	14.55	14.72	30000.10	0.322407	0
155	+ 75.25	+ 237.31	14.43	14.88	30000.3	0.413919	0
156	+ 15.06	− 191.94	14.41	14.83	30000.34	0.3591887	0
157	+ 1.77	+ 82.58	14.42	14.79	26523.370	0.4064970	
158	− 10.58	− 119.80	14.32	14.74	26472.442	0.3673350	
159	−2039.94	− 891.45	14.39	14.96	30000.0	0.343101	0

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 5139 (continued)							
160	− 711.13	+ 969.21	14.51	15.15	30000.1	0.397276	0
161	− 96.81	− 129.27	13.3	13.8		irr	
162	− 392.40	− 252.39	12.9	13.6		irr	cst now
163	− 575.24	+ 499.91	14.59	14.88	30000.0	0.3132294	0
164	+ 152.75	+ 478.38	13.7	14.0		37: †	Red
165	− 69.92	+ 104.59					
166	− 2.89	+ 144.71					
167	− 352.63	− 321.43					
168	− 543.66	− 201.42	14.96	15.46	30000.1	0.321295	0
169	+ 347.5	+ 278.7	14.61	14.85	32323.35	0.46926	Belserene
170						irr	Eggen, Herst 53
171	−2280	+2520				RRa	Wilkens 1
172	+ 720	+1440				RRa	Wilkens 2
173	+1800	+ 660				RRa	Wilkens 3
174	+ 780	−2040				1.8984	Wilkens 4, E
175	−2640	−3000					Wilkens 5
176	+ 144	− 66				RRc	Wilkens 6
177	+1380	− 480				RRb	Wilkens 7
178	+3120	+ 600				RRb	Wilkens 8
179	−1800	−2940				RRb	Wilkens 9
180	−1500	− 720				RRc	Wilkens 10
181	+1925	−1216				0.58836	Wess 2
182	+3355	+1292				0.54539	Wess 12
183	+1744	− 116				0.29605	Wess 13

* This variable appears intermediate between W Vir and RV Tau types, with alternate P $58^d.7$.
† Period from Dickens (1972).

Wilkens now considers his vars. 1, 5, 8, 9 also members (Letter, 1972), nos. 11–15 suspected. Wesselink has one field EW.

Belserene, Rutherfurd Contr 33.1, 43 (1956), AJ 64.58 (1959); Thackeray, Obs 80.226 (1960); Eggen, Royal Obs Bull 29.E73 (1961); Kurochkin, VS 13.248 (1961); Belserene, AJ 69.475 (1964); Dickens and Saunders, Royal Obs Bull 101.E101 (1965); Geyer, AG Mitt p.96 (1965); Geyer and Szeidl, Bamb Kl Veröff 4, 40.63 (1965); Harding, Royal Obs Bull 99.E65 (1965); Wilkens, MVS 3.72 (1965); Oosterhoff and Walraven, BAN 18.387 (1966); Ponsen and Oosterhoff, BAN Suppl 1.3 (1966); Woolley, Royal Obs Ann 2 (1966); Dickens and Carey, Royal Obs Bull 129 (1967); Geyer, ZAp 66.16 (1967); Wilkens, MVS 4.93 (1967); Jones, MN 140.265 (1968); Sistero, IBVS 316 (1968); Wilkens, La Plata Bol 12 (1968); van Albada, AAS Bull 1.366 (1969); Sistero, Fourcade and Laborde, IBVS 402 (1969); Wesselink, Letter (1969); Geyer and Szeidl, Astr and Ap 4.40 (1970); Geyer, IAU Coll 15.235 (1971); Dickens, Letter (1972); Dickens, Feast and Lloyd Evans, MN 159.337 (1972); Eggen, ApJ 172.639 (1972); Feast, Preprint (1972); Geyer, AG Mitt 31.168 (1972); Wesselink, unpub (1972); Wilkens, Letter (1972)

S55a, S57, S59, S61, A62, R62a, S62, P64, S64, L65, R65, FLA66, St66, S67, C&S69, S69, S70

NGC 5272 (Messier 3) $\alpha\ 13^h39^m.9$, $\delta\ +28°38'$

1	− 5.2	− 128.5	14.68	15.92	36692.336	0.5206250	–
2	+ 15.8	+ 52.6					
3	+ 57.9	− 66.0	14.75	16.00	15021.225	0.5582053	

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 5272 (continued)							
4	− 43.5	− 8.8	14.9	16.0			
5	+ 261.0	− 22.3	14.71	16.15	15021.239	0.5058940	Bℓ
6	− 123.9	+ 60.1	14.87	16.21	36669.320	0.5143228	+
7	− 4.8	+ 87.2	14.69	16.25	15021.064	0.4974290	
8	− 81.7	− 23.4	14.37	15.4			Confirmed
9	− 291.4	− 207.8	14.95	16.28	36668.502	0.5415641	−
10	+ 153.6	+ 138.0	15.06	16.15	36658.470	0.5695185	−
11	− 152.6	− 209.7	14.75	16.17	36699.491	0.5078918	cst
12	− 3.8	− 145.4	15.23	15.83	36687.336	0.3178890	
13	− 26.0	− 137.5	14.79	15.96	36702.398	0.4830302	− RR Binary?
14	− 49.0	− 161.0	14.95	16.19	36668.549	0.6359019	+
15	− 90.8	− 273.2	14.87	16.26	36666.565	0.5300794	+
16	− 301.4	− 93.1	14.93	16.31	36687.369	0.5115075	−
17	+ 142.4	− 440.4	15.20	16.20	36668.543	0.5761417	+, Bℓ
18	+ 97.6	− 295.3	14.86	16.30	36661.578	0.5163623	Bℓ
19	+ 350.5	− 245.6	15.56	16.15	36639.520	0.6319796	−
20	+ 333.5	− 271.6	14.85	16.25	36668.555	0.4912411	
21	+ 346.9	+ 17.9	14.81	16.27	30000.415	0.5157336	+
22	+ 190.2	− 10.7	14.98	16.20	36660.536	0.4814208	
23	− 113.0	+ 279.2	15.07	15.80	15021.082	0.5953756	
24	− 147.6	+ 10.4	15.06	16.07	15021.563	0.6633494	cst
25	− 124.4	− 31.4	14.66	16.07	15021.089	0.4800510	+
26	− 177.4	− 43.0	14.88	16.04	15021.239	0.5977452	−
27	− 110.2	− 102.8	15.07	16.11	15021.566	0.5790912	
28	− 25.0	− 105.8	14.92	15.88	24290.335	0.4706364	
29	− 65.2	− 73.6					
30	− 36.5	+ 58.0	15.18	15.92	22760.635	0.5120902	
31	+ 33.1	+ 65.1	14.43	15.65	15021.542	0.5807216	−
32	+ 11.8	+ 60.1	14.58	15.68	15021.108	0.4953518	−
33	+ 70.5	− 89.1	14.78	15.90	15021.217	0.5252237	−, Bℓ
34	+ 135.4	+ 170.2	15.08	16.16	36668.467	0.5591012	Bℓ
35	− 107.3	− 278.2	15.04	16.10	15021.032	0.5306059	Bℓ
36	+ 172.0	− 35.4	14.78	16.26	36692.525	0.5455855	+
37	− 236.7	+ 164.7	15.34	16.12	30000.241	0.3266384	−
38	− 203.0	+ 127.7	14.74	16.16	24290.304	0.5580276	−, Bℓ
39	− 243.6	+ 121.4	15.14	16.23	15021.073	0.5870766	Bℓ
40	− 271.2	+ 112.4	15.01	16.32	30000.397	0.5515416	
41	− 93.3	+ 54.0	15.22	16.23	15021.441	0.4850462	
42	− 78.6	+ 41.0	14.40	15.68	15021.515	0.5901852	
43	+ 99.9	+ 24.7	14.40	15.80	15021.191	0.5405790	Bℓ
44	+ 170.0	+ 99.4	14.84	16.04	15021.368	0.5063961	Bℓ
45	− 241.2	− 129.9	14.94	16.23	15021.349	0.5368966	
46	− 128.1	− 51.5	15.32	15.96	15021.264	0.6133669	
47	− 117.5	− 73.2	14.74	15.97	15021.459	0.5409923	Bℓ
48	+ 126.9	− 102.7	15.23	15.92	36669.346	0.6278128	
49	+ 140.0	− 100.7	14.71	16.11	36715.388	0.5482196	Bℓ
50	+ 8.8	− 234.0	14.57	16.09	36669.560	0.5130879	Bℓ
51	+ 30.8	− 226.4	15.16	16.18	36702.392	0.5839818	

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 5272 (continued)							
52	– 76.8	+ 152.0	14.92	16.06	15021.485	0.5162250	Bℓ
53	– 7.4	+ 122.8	14.68	15.93	15021.006	0.5048878	
54	– 32.6	+ 106.4	14.92	15.94	15021.193	0.5063150	
55	– 204.2	+ 324.4	14.88	16.31	30000.032	0.5298136	
56	– 141.1	+ 358.6	15.38	16.02	22760.623	0.3295986	
57	+ 155.2	– 0.2	14.84	16.23	15021.618	0.5122223	
58	– 86.2	+ 46.2	14.58	15.91	22760.621	0.5170617	
59	– 109.8	– 228.4	15.23	16.20	36699.425	0.5888053	
60	– 297.8	– 315.4	15.24	16.15	15021.389	0.7077228	
61	+ 190.2	+ 363.0	14.96	16.21	15021.076	0.5209312	Bℓ
62	+ 90.2	+ 417.0	15.42	16.16	15021.331	0.6524077	
63	+ 37.2	+ 341.9	14.96	16.22	15021.094	0.5704164	Bℓ
64	+ 114.8	+ 330.4	15.32	16.26	30000.382	0.6054590	
65	+ 125.4	+ 327.5	14.79	16.22	30000.332	0.6683394	
66	– 101.4	+ 121.4	15.20	15.93	15021.323	0.6201827	
67	– 131.4	+ 123.0	14.95	16.07	15021.411	0.5683609	Bℓ
68	+ 21.9	+ 174.8	15.0	16.0		0.3559732	Bℓ
69	+ 80.6	+ 141.0	15.15	16.05	36692.851:	0.5665878	
70	+ 37.6	+ 152.2	15.22	15.75	15021.315	0.486:	Bℓ
71	+ 160.6	– 2.0	15.07	16.04	15021.168	0.5490517	
72	+ 445.5	– 2.2	14.80	16.30	15021.327	0.4560739	
73	+ 438.5	+ 62.2	15.0	16.0			
74	+ 88.2	+ 151.0	14.80	16.20	36668.389	0.4921441	
75	+ 49.0	+ 159.5	15.38	15.98	36668.411	0.3140790	
76	– 14.4	– 88.2	14.90	16.46	15021.293	0.5017544	
77	– 94.4	+ 27.8	14.63	16.07	15021.451	0.4593425	
78	+ 47.5	+ 66.4	14.92	15.70	15021.249	0.6119254	
79	+ 43.4	+ 349.4	14.72	16.31	15021.229	0.4833275	Bℓ
80	+ 416.8	+ 284.6	14.80	16.17	15021.433	0.5384827	Bℓ
81	+ 342.8	+ 351.1	14.86	16.30	30000.461	0.5291108	
82	– 102.6	– 601.8	14.96	16.31	36668.477	0.5245061	
83	– 441.6	+ 113.4	14.87	16.32	15021.046	0.5012408	
84	+ 64.0	+ 165.2	15.26	16.12	36666.463	0.5957289	
85	+ 306.2	+ 225.8	15.32	15.92	22760.517	0.3558189	
86	+ 513.0	– 114.2	15.42	16.06	15021.016	0.2926601	
87	+ 110.6	+ 60.2	15.13	15.68	22760.535	0.3574814	
88	– 35.0	– 70.2	15.08	15.67	24290.324	0.2985092	
89	+ 28.0	– 110.8	14.85	15.93	15021.507	0.5484779	
90	+ 97.2	– 188.2	14.92	16.25	36692.397	0.5170334	
91	– 14.3	– 550.0	14.95	16.26	36669.366	0.5301630	
92	– 29.0	– 408.4	14.94	16.30	15021.083	0.5035553	
93	– 319.4	– 396.6	15.24	16.27	30000.420	0.6023007	
94	488.4	– 224.6	14.90	16.33	30000.304	0.5236936	
95	– 154.7	+ 15.4	13.73	14.42		103.19	
96	– 164.2	– 234.0	14.74	16.10	36692.470	0.4994467	
97	130.0	– 196.7	15.53	16.04	[illegible] 61.581	0.3349289	
98	+ 132.4	– 3.2	not var				
99	+ 201.8	– 55.0	14.8	15.8			

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 5272 (continued)							
100	+ 69.9	+ 97.3	15.31	15.96		0.6188126	
101	+ 46.4	+ 83.7	15.29	15.78	15021.101	0.6438975	
102	+ 58.4	+ 114.9	15.2	15.9	var?		
103	+ 58.1	+ 120.4	not var				
104	− 25.8	+ 145.5	14.73	15.99	15021.288	0.5699231	
105	− 20.9	+ 191.6	15.33	15.72	36668.548	0.2877427	
106	− 48.0	+ 168.0	15.18	16.04	36666.372	0.5471593	
107	− 75.8	+ 335.0	15.40	16.14	30000.039	0.3090348	
108	− 219.0	+ 310.9	14.94	16.30	30000.250	0.5196047	
109	− 89.3	+ 2.7	14.56	15.64	15021.033	0.5339239	
110	− 99.4	− 15.8	15.02	15.88	15021.397	0.5353569	
111	− 92.7	+ 21.9	15.06	16.02	15021.402	0.5102469	Bℓ
112	− 144.6	− 719.4	not var				
113	+ 199.8	− 689.8	14.90	16.25	15021.241	0.5130066	
114	+ 11.8	+ 622.0	15.18	16.24	15021.515	0.5977270	
115	+ 445.0	+ 664.7	14.98	16.34	15021.297	0.5133529	
116	− 491.8	+ 465.2	14.89	16.32	15021.441	0.5148088	
117	+ 89.6	− 467.6	15.22	16.22	15021.579	0.6005164	
118	+ 144.4	− 292.2	14.90	16.36	15021.272	0.4993807	
119	+ 253.4	+ 106.2	14.76	16.25	30000.192	0.5177411	
120	− 295.8	+ 231.4	15.56	16.07	15021.284	0.6401387	
121	− 43.6	+ 56.1	14.84	15.54	22760.550	0.5351882	
122	− 33.5	− 46.4	14.6	16.1		0.5017	
123	− 259	− 985	14.92	16.31	15021.395	0.5454472	
124	− 66.4	− 201.4	15.50	15.96	36685.349	0.7524328	
125	+ 186.3	− 132.8	15.48	16.00	36666.585	0.3498206	
126	− 15.4	− 146.4	15.42	15.96	15021.208	0.3484043	
127	+ 95.6	− 63.6	not var				
128	+ 114.6	+ 131.4	15.40	15.86		0.2922710	Bℓ
129	− 43.6	+ 77.2	15.2	16.1		0.305471	
130	+ 4.2	+ 84.6	15.27	16.00	22760.347	0.5688172	Bℓ
131	− 73.2	+ 27.4	15.04	15.56	15021.318	0.2976919	
132	− 53.6	− 22.0	15.3	16.4	24290.387	0.3398479	
133	− 58.6	+ 43.5	14.89	15.96	15021.482	0.5507230	
134	− 22.4	+ 52.4	14.9	16.3	24290.282	0.6190	
135	− 27.0	+ 38.0	15.0	16.5		0.56843	
136	− 25.4	+ 33.4	15.6	16.2			
137	+ 53.0	− 18.8	15.30	16.04	15021.155	0.5751464	
138	− 263.6	+ 41.9	14.0	14.46	35608.96	80.98	
139	+ 34.5	+ 28.0	15.25	16.12	22760.465	0.560004	
140	− 15.7	+ 108.9	15.07	15.51	22760.216	0.3331304	
141	−1497.5	− 249.9	14.98	15.97		0.2695671	RV CVn, EW, f
142	− 30	− 59	14.79	15.72	24290.397	0.5686256	
143	− 34	+ 16	15.4	16.4	24290.337	0.51111	
144	+ 54	− 100	15.27	15.99	24290.565	0.5967843	
145	+ 29	+ 8	14.9	16.5	24290.528	0.514456	
146	+ 96	− 59	14.6	16.5	24290.563	0.596740	
147	− 21	+ 46	15.1	16.3	24290.005	0.34644	

No.	x″		y″		Max.	Min.	Epoch	Period	Remarks
NGC 5272 (continued)									
148	–	7	+	37	15.3	16.4	24290.170	0.467246	
149	+	34	+	52	14.7	16.5	24290.228	0.54985	
150	+	69	+	37	14.8	16.7	24290.359	0.52397	
151	+	4	–	40	14.9	16.3	24290.191	0.51705	
152	+	77	+	50	15.42	15.76	24290.355	0.3261217	
153	–	38	+	60	not var				
154	+	2	–	29	12.1	13.7	38873.53	15.290	
155	–	64	–	74					
156	–	21	–	42	15.0	15.9	38872.331	0.531979	
157	–	17	+	35	14.2	15.7	24647.650:	0.5283	
158	–	16	–	41	15.2	16.5	24647.564:	0.50809?	
159	–	15	+	16	14.9	16.6	24647.602:	0.5337	
160	–	9	–	44	14.9	16.1	24647.446	0.64792	
161	+	17	–	58	15.4	16.4	24647.567:	0.49874	
162	+	28	–	32	not var				
163	–	16	–	32	not var				
164	+	21	–	36	15.3	15.9			
165	+	73	–	20	14.7	16.5	24647.544	0.483638	
166	–	97	–	8	15.4	16.1	38867.364	0.485622	
167	–	78	–	37	15.62	16.00	24647.448	0.6439839	
168	–	45	+	7	14.9	16.0	24647.617	0.3770	
169	–	29	–	35	not var				
170	–	28	+	32	15.1	16.1	24647.716:	0.43725	
171	–	27	+	16	15.0	16.1	24647.864	0.4303	
172	–	21	+	25	14.9	16.5	24647.700	0.59400	
173	–	13	+	39	15.2	16.6	24647.670:	0.606990	
174	–	9	–	34	15.1	16.1	24647.710	0.4082	
175	+	42	+	26	14.9	16.2	24647.914	0.60780	
176	+	46	+	32	14.8	16.4	24647.621	0.55599	
177	+	63	–	29	15.52	15.90	24647.953	0.3483438	
178	+	79	+	46	15.51	15.81	24647.755	0.2650805	
179	+	39	–	774	not var				
180	–	19	–	27	not var				
181	–	30	–	14	not var				
182	–	19	+	60	not var				
183	+	29	+	7	not var				
184	–	25	–	14	14.9	16.4	24647.841	0.517	
185	–	15	+	32	15.2	16.1			
186	+	12	–	64	15.1	16.1	24647.670	0.675	
187	–	23	+	9	14.9	16.2	24647.961	0.3927	
188	–	27	+	24	15.0	16.0	24647.615:	0.3677	
189	–	25	–	21	15.2	16.0	24647.964	0.668	
190	–	8	+	28	14.8	16.5	24647.936	0.501	
191		0	+	24	15.1	16.1	24647.981	0.512	
192	–	2	+	3	15.0	16.1	24647.933:	0.525	
193	+	15	–	7	14.8	16.3	24647.777	0.630	
194	+	17	–	13	15.1	16.4	24647.758	0.549	
195	–	13	–	29	15.0	16.2	24647.470:	0.600	

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 5272 (continued)							
196	+ 47	+ 1					
197	+ 58	+ 10	15.1	16.5	24647.689	0.500075	
198	− 23	+ 15	15.2	16.0	24647.923:	0.3617	
199	− 19	+ 13	14.8	16.3	24647.699:	0.488	
200	− 4	+ 21					
201	+ 4	− 9	15.1	16.1	39964.391	0.541333	
202	− 379.7	+ 101	15.4	15.8		0.9987:	
203	− 30.2	− 308	15.56	15.72		0.28719	
204	− 106.4	− 18	15.76	15.90		0.9170:	
205	− 780	+ 720	15.4	16.2	35600.38	0.6369126	vZ 89
206	0	−1680	14.8	16.1	35601.41	0.5093832	vZ 1221
207	+ 36.0	− 30.8	14.8	15.4			vZ 991
208	+ 2.5	− 57.9	14.8	15.4			vZ 800
209	− 68.2	− 99.1	14.3	15.1			vZ 472
210	− 85.7	− 9.9	14.6	15.4			vZ 420
211	− 54.1	+ 6.6	14.6	15.7	41061.438	0.557798	vZ 519
212	− 21.6	− 38.0	15.2	16.2	38867.356	0.542196	SVS 1365
213	− 25.4	− 29.7	15.0	15.4			vZ 648?
214	+ 32.0	+ 5.8	14.6	15.6	41061.447	0.539493	vZ 971
215	− 13.9	− 0.9	14.8	15.6			vZ 717
216	+ 27.9	− 10.8	15.2	15.8			vZ 951
217	0.0	− 26.4	14.5	15.4			SVS 1370
218	+ 28.1	− 29.4	14.5	15.7	38867.304	0.543774	vZ 950
219	− 57.9	+ 15.7	14.6	15.8			vZ 509
220	+ 33.1	− 15.2	14.2	14.8			vZ 978
221	− 16.6	− 13.5	14.6	15.1			vZ 692
222	+ 96.3	− 63.3	14.9	15.9	38859.416	0.596764	vZ 1198
223	+ 23.9	− 5.8	14.8	15.4			vZ 930
224	− 22.1	+ 5.0	13.7	14.6			vZ 668
225	+ 8.8	+ 225	13.86	14.26	35651.38	89.59	vZ 837

Vars. 205. 206 found by Kurochkin, identified by Kukarkin; 207-224 by Kholopov; 225 by Russev. Variability of V8 and V156 reconfirmed by Kholopov, and of V138 by Russev. 11 suspected variables, Kholopov (1963). Identification of variables in this cluster is difficult. See von Zeipel numbers in S55a, with revisions by Kholopov (1963), and above for the new variables.

Arp, AJ 60.1 (1955); Roberts and Sandage, AJ 60.185 (1955); Osváth, Budapest Mitt 42 (1957); Kukarkin and Kukarkina, VS 12.291 (1958); Wallerstein, ApJ 127.583 (1958); Kurochkin, AC 205 (1959); Sandage, ApJ 129.596 (1959); Kraft, Camp and Hughes, ApJ 130.90 (1959); Kukarkin, AC 216.29 (1960); Kurochkin, VS 13.84 (1960); Thackeray, Obs 80.226 (1960); Kurochkin, VS 13.248 (1961); Kukarkina and Kukarkin, VS 13.309 (1961); Kurochkin, VS 14.196 (1962); Breckinridge, ASP 75.22 (1963); Kholopov, VS 14.275 (1963); Fernie, ApJ 141.1411 (1965); Feast, ApJ 142.796 (1965); Szeidl, Budapest Mitt 58 (1965); Kheylo, IBVS 171 (1966); Sturch, ApJ 143.774 (1966), AJ 72.321 (1967), ApJ 148.477 (1967); Kheylo, Problems in Astrophysics, Kiev, p. 62 (1968), NASA Tech Tr F598.57 (1971); van Albada, AAS Bull 1.366 (1969); Zhukov, Soviet Astr AJ 13.306 (1969); Kukarkin and Kukarkina, VS 17.157 (1970); Coutts, Bamb Veröff 9, 100.238 (1971); Kholopov, AC 640.3 (1971), AC 651.7 (1971), AC 652.7 (1971); Russev, VS 18.171 (1971); Kholopov, AC 676.7 (1972), Letter (1972); Szeidl, Letter (1972)

S55a, S57, S59, S61, A62, R62a, S62, P64, S64, L65, R65, St66, S67, C&S69, S69, S70, F72

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks

NGC 5286 α 13^{h}43^m.0, δ −51°07′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	− 46.20	+145.48					
2	+ 78.10	− 42.63					
3	+256.58	− 39.60					
4	− 69.30	− 70.95					
5	+ 64.63	+ 27.78					
6	+ 60.23	− 33.00					
7	+ 24.48	− 60.23					
8	+ 16.50	− 35.75					

All above variables found by Fourcade and Laborde. One field variable, Bailey.

Bailey, HB 801 (1924); Fourcade and Laborde, Cordoba Repr 117 (1964), Cordoba Repr 126 (1965); Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966)

S55a, S59, R62c, S62, F&L63, S67, S69

NGC 5466 α 14^{h}03^m.2, δ +28°46′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+858	− 95	15.80	16.80	40706.387	0.5774192	+
2	− 62	−110	15.77	16.77	40683.342	0.5885020	−, Bℓ
3	− 31	− 8	15.90	16.76	40704.319	0.5780638	cst
4	− 80	+ 9	15.69	17.03	40704.461	0.5120111	+, −, Bℓ
5	− 64	+112	15.85	17.10	39945.659	0.6152674	−
6	+122	− 24	15.60	16.60	40705.408	0.6206610	−
7	−210	−225	15.94	16.90	40702.398	0.7034205	cst
8	+ 23	− 6	15.81	16.70	40705.358	0.6291182	cst
9	+ 31	+ 15	15.74	16.77	39947.328	0.6850240	−
10	+ 85	+ 46	15.87	16.90	40705.468	0.7092735	cst
11	+117	+ 68	16.09	16.70	40705.285	0.3779938	cst
12	+ 17	− 88	16.09	16.66	39945.210	0.2942387	cst
13	− 49	− 73	16.10	16.80	40736.379	0.3415476	+
14	− 47	+ 52	15.86	16.70	39947.568	0.7858598	−
15	+223	+ 20	16.31	16.69	40705.223	0.4015471	−, +
16	−149	−175	16.04	16.74	39945.372	0.2966414	−
17	− 60	− 30	16.05	16.58	40706.394	0.3701037	+
18	+ 44	+ 41	16.0	16.7	30519.697	0.37406	
19	+157	−166	14.40	14.95	40705.737	0.8212879	Hop 216, f
20	−228	+ 45	16.42	16.72			Cuffey
21	+ 47	− 10	16.53	16.74			Cuffey
22	−153	− 80	16.08	16.65	40705.364	0.265687	Hop 35
23	+329	+ 15	16.50	16.73	40705.126	0.2321607	Hop 235, cst

Baade nos. 3, 4, 5 in corona considered probable members by Kukarkin and Kholopov. Cuffey 3-5-2-72 is considered field variable.

Kukarkin, VS 12.50 (1959); Cuffey, AJ 66.71 (1961), Letters (1961); Kurochkin, VS 13.248 (1961), VS 13.331 (1961); Kholopov, VS 14.71 (1962); Kurochkin, VS 14.196 (1962); Bartolini, Biolchini and Mannino, Bologna Pubbl 9, 4 (1965); Gryzunova, AC 526.8 (1969), VS Suppl 1.253 (1972)

S55a, S57, S59, S61, R62a, S62, S64, L65, R65, S67, C&S69, S69

NGC 5634 α $14^h27^m.0$, δ −05°45′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	−56.5	− 19.5	16.41	17.39		0.65872	
2	−25.4	+ 83.1	16.19	17.38			
3	−45.1	+ 41.9	16.48	17.47			
4	+54.2	− 65.2	16.55	17.39			
5	−11.6	−162.9	16.72:	17.19			
6	+43.4	− 52.6	16.69	17.05:			
7	− 0.4	− 4.0					

Baade, Mt Wils Contr 706 (p) (1945)
S55a, S59, S62, L65, S69

NGC 5694 α $14^h36^m.7$, δ −26°19′

No variables found.
Baade, ASP 46.52 (1934)
S55a, S59, R62c, S62, S69

IC 4499 α $14^h52^m.7$, δ −82°02′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+ 84.15	− 3.03					
2	+ 41.53	− 96.25					
3	− 90.75	−104.50					
4	− 33.55	− 14.03					
5	− 38.23	− 47.58					
6	− 2.75	+ 34.38					
7	+ 24.75	+203.50					
8	+ 88.00	+ 97.08					
9	+ 72.60	+105.60					
10	+ 11.00	+ 68.75					
11	+ 95.15	− 29.98					
12	+112.75	+ 62.15					
13	+ 44.28	17.33					
14	+ 22.83	− 19.25					
15	− 6.88	− 9.08					
16	− 66.00	+ 52.25					
17	− 22.00	+ 14.58					
18	62.15	− 22.28					
19	−159.50	− 21.73					
20	− 22.27	+159.23					
21	+ 85.53	+145.75					
22	+270.33	+ 64.35					
23	+ 93.50	− 38.50					
24	− 35.75	31.63					
25	−118.25	− 6.32					
26	−168.58	+159.50					
27	+ 19.53	+111.38					
28	− 11.55	− 44.28					

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
IC 4499 (continued)							
29	+ 41.25	− 13.75					
30	+ 85.25	− 33.55					
31	+ 35.75	+ 95.70					
32	+ 77.00	− 11.28					
33	+ 59.12	−273.35					
34	+ 88.00	−123.75					
35	+ 73.98	+101.75					
36	+159.78	+ 6.33					
37	+ 15.95	− 56.10					
38	− 85.25	+ 56.38					
39	+ 1.10	+ 39.05					
40	+128.98	+280.50					
41	+ 40.43	+178.75					
42	+115.50	− 22.83					
43	+ 64.90	−233.75					
44	− 62.98	+ 61.88					
45	+105.33	+250.53					
46	−133.10	−236.50					
47	+ 37.40	− 93.50					
48	+ 64.90	− 2.75					
49	+ 11.55	− 99.28					
50	+102.03	− 46.75					
51	+ 68.20	+ 9.90					
52	+ 63.53	+178.20					
53	+121.55	−110.00					
54	+ 93.78	−237.33					
55	− 46.75	− 31.08					
56	− 31.63	− 9.63					
57	− 6.05	+ 55.00					
58	− 58.30	− 67.65					
59	+ 71.23	− 42.08					
60	+ 2.75	+ 54.45					
61	+ 1.93	+ 57.48					
62	+258.23	− 88.23					
63	− 99.00	− 68.20					
64	+ 94.60	+ 57.20					
65	+ 30.25	− 93.50					
66	+132.00	+ 79.48					
67	+ 51.70	− 13.75					
68	− 25.03	+221.10					
69	−113.30	+ 19.25					
70	+ 66.28	− 18.15					
71	− 30.80	− 25.03					
72	− 8.25	− 69.03					
73	+234.58	−280.50					
74	+ 22.00	+ 66.28					
75	+ 16.50	− 63.25					

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
IC 4499 (continued)							
76	+333.30	+293.15					
77	+ 79.20	+ 52.25					
78	−187.00	+104.50					
79	−159.50	+316.25					
80	+ 33.00	−283.80					
81	+ 45.10	− 11.00					
82	+ 22.55	+ 8.25					
83	+ 19.53	+ 31.08					
84	− 24.48	− 41.53					
85	− 91.30	+309.93					
86	+ 69.85	+ 13.20					
87	+ 34.93	+ 73.98					
88	+ 85.25	+ 50.60					
89	− 68.75	− 0.83					
90	+ 3.30	− 19.25					
91	− 61.05	− 24.75					
92	+123.48	+138.05					
93	+ 35.75	− 32.18					
94	+ 15.50	+ 55.83					
95	− 37.40	+ 38.78					
96	− 8.53	+ 29.98					
97	− 45.93	− 88.28					
98	+251.08	− 44.55					
99	−292.05	+ 4.68					
100	+ 72.60	−266.20					
101	+ 35.75	− 20.35					
102	+ 36.03	+ 7.15					
103	+ 35.48	+ 52.25					
104	+ 63.80	+ 30.53					
105	+ 72.60	− 3.30					
106	+ 30.25	+133.93					
107	+159.23	− 81.68					
108	+121.28	+ 6.33					
109	− 96.53	+ 97.63					
110	+ 38.50	+ 82.23					
111	+ 49.50	−158.13					
112	− 30.25	+ 63.25					
113	+156.75	+226.88					
114	− 7.98	− 13.75					
115	+ 33.28	+119.08					
116	+ 30.25	− 31.90					
117	−242.28	+234.85					
118	+168.03	+181.50					
119	− 71.50	+ 13.50					
120	+ 85.53	−220.00					
121	− 96.25	− 31.63					
122	+ 11.00	− 20.63					

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
IC 4499 (continued)							
123	+164.45	+ 17.33					
124	+ 10.73	+197.73					
125	+130.35	+131.18					
126	+ 18.98	− 59.95					
127	+ 49.50	− 10.45					
128	+ 77.00	− 38.78					
129	− 13.20	− 39.60					

All variables found by Fourcade and Laborde, who also have suspected variables nos. 130-169 with coordinates, and no. 170.

Fourcade and Laborde, Cordoba Repr 126 (1965); Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966); Fourcade and Laborde, Cordoba Repr 173 (p) (1969)

S55b, R62b, F&L63, S67, S69, S70

NGC 5824 α $15^h00^m.9$, δ $-32°53'$

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	− 72.8	+ 35.5	16.8	18.3	35638.20	0.597	
2	+ 11.3	+113.1	17.1	18.2	35635.48	0.651	
3	+124.7	+ 32.0	17.1	18.2	35636.42	0.641	
4	+186.5	+ 74.0	17.1	18.0			RRc?
5	− 9.5	+108.0	17.0	18.1	35638.21	0.634	
6	+ 98.6	− 34.2	17.2	18.1			RRc
7	− 36.9	− 71.6	17.4	18.0			RR
8	− 8.7	− 69.4	17.7	18.3			RR
9	+ 75.8	+ 72.2	16.9	18.3			RRa
10	+155.9	−113.0	17.3	18.0			RR
11	− 10.1	− 50.8	16.9	17.9			
12	− 73.3	− 40.0	17.0	18.2	35661.30	0.592	
13	+ 14.0	−106.1	17.4	18.0			RR
14	+ 19.0	+ 51.0	17.1	17.9		0.35?	RRc
15	+ 82.5	− 58.1	17.2	18.3			RR
16	+ 4.1	− 63.4	17.5	18.3			RR
17	+ 33.7	− 90.3	17.3	18.2			RRc
18	+132.9	− 3.6	17.1	18.2			RR
19	− 29.1	− 42.6	17.0	18.3	35636.22	0.635	RRa
20	− 82.1	− 19.8	17.5	18.1			
21	+ 45.2	+ 71.1	17.6	18.2			RR
22	+ 48.5	− 15.9	17.1	18.0		0.6	RRa
23	−125.6	−243.2	17.0	18.1	35630.23	0.618	
24	+ 96.3	−305.6	17.2	18.0			RRc
25	−333.4	+ 6.5	17.3	18.1			RR
26	+401.5	+362.9	17.0	18.1	35635.45	0.744?	RRa
27	+326.1	− 24.5	17.2	18.1			RR

All variables found by Rosino.

Rosino, ASP 73.309 (1961)

S55b, R57, S61, S62, S64, R65, FLA66, S69

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks

Palomar 5 α 15^{h}13^m.5, δ +00° 05′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	− 97	+ 25	17.50	17.92	33741.651	0.293230	
2	− 85	−246	17.61	18.01	34456.084	0.332467	
3	+143	−166	17.45	17.95	34182.801	0.329953	
4	+ 35	−238	17.45	17.93	34234.522	0.286362	
5	− 84	+ 94	17.55	17.85	34833.520	0.252395	

Pietra, Bologna Pubbl 6, 16 (1956); Mannino, Bologna Pubbl 6, 17 (1956); Kinman and Rosino, ASP 74.500 (1962); Rosino and Pinto, IAU Coll 21 (1973)
S55a, R57, S59, R61, S62, S64, R65, S69

NGC 5897 α 15^{h}14^m.5, δ −20° 50′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	−109	−201	16.15	17.1	41100.695	0.4430685	
2	− 57	− 97	16.25	16.9	36752.627	0.454149	var
3	− 40	− 4	16.3	17.1	33481.615	0.419455	+
4	+ 71	+ 20	15.7	16.2	40807.611	0.42	
5	−136	+215	14.85	15.2	40807.611	64.5 irr	
6	+ 16	+ 59	16.4	16.9	41124.663	0.3325?	Alt 0.485
7	+ 20	+ 58	16.2	16.8	40803.536	0.511710	

Vars. 5-7 found by Sandage and Katem. Two suspected variables.
Sandage and Katem, ApJ 153.569 (1968); Eggen, ApJ 172.639 (1972); Wehlau, Sawyer Hogg and Potts, JRASC 66.72 (1972), unpub (1972)
S55a, S57, S59, S62, S69, S70

NGC 5904 (Messier 5) α 15^{h}16^m.0, δ +02° 16′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+ 27.7	+161.1	14.66	15.69	13715.588	0.5217865	+
2	− 343.5	− 31.5	14.17	15.57	39256.416	0.5262679	B♀
3	+ 160.1	+113.7	14.62	15.47	36762.676	0.6001888	+
4	− 12.3	+ 73.8	14.65	15.89	27627.708	0.4496402	
5	− 7.8	+ 51.6	14.83	16.06	27567.929	0.545903	
6	+ 27.2	− 46.6	14.55	15.61	27567.856	0.5488311	−
7	− 5.1	−191.3	14.03	15.69	27601.730	0.494396	+
8	+ 134.0	−133.2	14.67	15.75	39942.309	0.5462306	+
9	+ 195.0	+ 88.0	14.57	15.50	27610.686	0.6988972	+
10	+ 107.4	+382.0	14.23	15.45	36762.591	0.5306602	−
11	− 154.5	+ 84.5	14.27	15.60	36762.605	0.5958939	+
12	− 175.5	− 17.3	14.20	15.78	27601.762	0.467716	−
13	+ 11.0	− 65.4	14.75	15.64	27567.800	0.5131223	+
14	− 145.6	+103.7	14.30	15.62	27610.358	0.4871724	−, B♀
15	+ 192.0	+ 3.6	14.70	15.28	27567.908	0.336763	+
16	+ 91.0	+ 83.9	14.29	15.53	27567.781	0.6476223	+
17	− 26.1	+ 44.3	14.80	15.91	27567.723	0.601354	
18	+ 151.7	−107.7	14.33	15.55	38911.175	0.464098	+
19	+ 233.7	−129.9	14.38	15.57	27601.706	0.469965	+
20	− 255.5	− 25.0	14.38	15.56	36762.787	0.6094778	+
21	+ 322.6	+ 74.0	14.38	15.38	13715.505	0.6048947	+
22	− 205.7	+383.5	not var				

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 5904 (continued)							
23	− 253.4	− 10.9	not var				
24	− 46.8	− 71.7	14.77	15.65	27567.821	0.4783771	
25	− 28.9	−128.0	13.83	14.73	27567.766	0.508	
26	+ 21.8	+101.5	14.42	15.46	27601.761	0.6225642	
27	− 6.7	− 59.2	14.37	15.74	27888.894	0.4703	
28	+ 132.2	−121.1	14.49	15.59	36762.271	0.5439272	−
29	− 374.7	− 76.6	14.42	15.53	27567.700	0.451433	−, Sp F
30	+ 22.8	−212.8	14.55	15.55	39942.454	0.5921739	−
31	+ 151.7	−141.7	14.77	15.48	13715.209	0.30058294	cst
32	+ 201.9	−150.6	14.10	15.67	13715.596	0.45778654	cst
33	− 21.1	+127.5	14.57	15.63	27610.270	0.5014750	+
34	+ 84.3	+ 59.5	14.65	15.52	27567.727	0.5681431	cst
35	− 12.2	−114.7	14.80	15.39	27610.406	0.3081255	+
36	− 8.4	− 52.2	14.96	15.91	27563.868	0.6277229	cst
37	+ 44.7	− 67.0	14.49	15.60	27605.762	0.4887941	
38	− 44.2	+117.2	14.49	15.90	27889.937	0.470441	
39	− 125.3	−205.2	14.08	15.63	27610.368	0.5890374	+
40	+ 124.8	+113.5	14.84	15.45	27610.461	0.3173299	+
41	+ 19.3	+231.4	14.19	15.57	27567.879	0.488572	−
42	− 123.2	−120.8	11.20	12.24	27567.8	25.738	Sp, V, mem
43	− 201.8	+154.3	14.70	15.43	27610.364	0.6602289	+
44	− 102.5	+ 31.1	14.97	15.61	27610.125	0.3296024	+
45	− 116.7	+ 65.7	14.74	15.90	27567.774	0.6166364	cst
46	− 80.0	+ 69.1	not var				
47	− 75.3	+ 58.1	14.84	15.96	27563.861	0.5397295	−
48	− 62.5	+106.3	not var				
49	+ 52.7	+177.5	not var				
50	+ 38.0	+109.1	14.00:	14.54:		irr?	Sp
51	+ 0.3	+135.5	var?				
52	+ 107.9	+ 35.3	14.49	15.57	27563.804	0.5017848	Bℓ
53	+ 68.9	+ 19.2	14.98	15.28	27601.70	0.37360	
54	+ 30.3	+ 57.2	14.62	15.68			
55	+ 80.1	−163.2	14.87	15.39	36762.219	0.3289013	+
56	− 68.9	+ 96.5	14.75	15.86	27889.931	0.5346903	
57	− 30.6	+ 99.7	14.94	15.43	27567.897	0.28467869	
58	− 605.1	+168.2	14.86	15.52	36762.274	0.4912489	+
59	− 150.0	− 35.5	14.70	15.67	13715.490	0.5420257	+
60	− 109.7	+ 8.2	15.04	15.74	27567.75	0.285218?	
61	− 254.9	− 31.4	14.42	15.62	27610.472	0.5686267	+
62	+ 166.8	−216.8	14.78	15.36	36762.543	0.2814154	+
63	+ 212.9	+ 51.8	14.10	15.50	13384.553	0.4976783	+, Bℓ
64	− 51.2	−248.9	14.43	15.55	27610.553	0.5445006	−
65	− 159.9	− 93.8	14.07	15.02	36385.522	0.4806936	+
66	+ 218.3	+406.8	14.83	15.42	27610.242	0.3507086	+
67	−1028.2	− 59.8	14.36	15.13	13715.314	0.3490944	−
68	+ 897.5	+ 47.6	14.87	15.47	27610.347	0.3342667	−
69	+ 653.3	+751.6	14.10	15.68	27610.320	0.4948729	−
70	+ 393.8	+626.4	14.54	15.70	27610.365	0.5585490	−

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 5904 (continued)							
71	+ 664.1	+290.3	14.25	15.86	27610.357	0.5024724	–
72	+ 689.7	+ 38.3	14.66	15.71	27610.318	0.5622722	–, Sp F
73	+ 17.3	+604.7	14.66	15.23	19533.289	0.3401261	+
74	+ 202.8	+162.8	14.83	15.18	36762.379	0.4539887	–
75	+ 78.6	–412.8	14.80	15.38	27610.523	0.6854171	+, Sp F
76	+ 80.5	–309.2	14.69	15.18	13524.125	0.3018963	–
77	– 171.5	–184.8	14.39	15.25	36762.596	0.845146	+
78	+ 65.5	+159.7	14.90	15.46	39942.389	0.26481739	cst
79	– 133.5	– 32.2	14.88	15.42	39942.316:	0.33313838	cst
80	– 48.6	+111.6	15.05	15.54	27562.986	0.3365424	–
81	– 72.2	–121.7	14.61	15.58	34131.439	0.5572965	–
82	– 67.8	+ 12.4	14.86	15.72	27563.798	0.5584455	
83	– 84.7	– 87.8	14.80	15.66	27567.783	0.5533073	cst
84	+ 43.7	– 31.9	11.54	12.61	27602	26.42 ±	Sp, V, mem
85	+ 38.3	– 34.4	14.80	15.70	27567.970	0.52741	
86	+ 34.6	– 33.0	14.50	15.83	27567.856	0.56733	
87	+ 122.0	– 1.8	15.00	15.38	21350.182	0.7383992	+
88	+ 65.2	+ 61.8	15.08	15.48	27563.832	0.32808270	
89	+ 60.0	+ 64.7	14.79	15.69	27626.707	0.55844189	
90	– 44.7	+ 15.3	14.67	15.88	27540.828	0.5571527	
91	– 36.0	+ 35.0	15.04	15.96	27567.927	0.584944	
92	– 56.6	–123.5	14.28	15.58	27567.963	0.4635789	
93	+ 44.0	– 35.7	14.54	15.81	27567.771	0.55231	
94	– 23.5	+ 17.4	15.26	16.11	27601.728	0.53141	
95	– 47.2	+102.8	15.13	15.80	27626.689	0.29082	
96	– 12.4	+ 32.9	14.96	16.15	27563.778	0.51225	
97	+ 48.9	– 92.5	14.18	15.61	27601.754	0.54466	
98	+ 37.3	+ 20.0	15.26	15.71	27605.737	0.3063857	–
99	+ 34.4	– 0.1	15.32	15.89	27567.739	0.32134	
100	+ 2.8	+ 48.7	15.30	16.01	27628.710	0.29434	
101	– 281.6	+ 36.0	17.15	22			UG?
102	+ 14.8	– 14.8					prob RR
103	+ 20.5	– 8.8					prob RR

Five suspected variables, Voroshilov (1971); one suspected, Osborn (1971).

Arp, AJ 60.1 (1955), AJ 62.129 (1957); Wallerstein, ApJ 127.583 (p) (1958), ApJ 129.356 (1959); Kraft, Camp and Hughes, ApJ 130.90 (1959); Preston, ApJ 134.651 (1961); Williams, AJ 71.615 (1966); Coutts, Doctoral Thesis, Toronto (1967); Sturch, ApJ 148.477 (1967); Wilkens, Inf Bull So Hemis 12.17 (1968); Coutts, Non-Periodic Phenomena in Variable Stars, ed. L. Detre, Budapest, p. 313 (1969); Coutts, Margoni and Stagni, AAS Bull 1.238 (1969); Coutts and Sawyer Hogg, Toronto Publ 3, 1 (1969); Kukarkin and Kukarkina, AC 541.1 (1969); Sturch, AJ 74.82 (1969); Zhukov, Soviet Astr AJ 13.306 (1969); Coutts Toronto Publ 3.81 (1971), IBVS 572 (1971); Kukarkin, AC 646 (1971); Kukarkin and Kukarkina, VS Suppl 1, 1 (1971); Osborn, IBVS 598 (1971); Voroshilov, AC 623.7 (1971); Coutts, Bamb Veröff 9, 100.238 (1972); Coutts and Sawyer Hogg, AAS Bull 4.217 (1972); Eggen, ApJ 172.639 (1972)

S55a, R57, S57, S59, S61, A62, R62a, S62, P64, S64, L65, R65, St66, S67, S69, S70, F72

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks

NGC 5927 α 15^{h}24^m.4, δ −50°29′

1	+141.90	+129.25					L&F 4, f?
2	− 45.38	0.0					L&F 14
3	− 4.6	− 4.1				300:	Osborn
4			14.6	15.3			V3, LE&M
5			14.7	15.2			V6, LE&M
6			14.7	15.3			V7, LE&M
7			14.7	15.3			V8, LE&M
8			15.0	15.6			V9, LE&M
9			15.1	16.0			V10, LE&M
10			14.7	15.1			L43, LE&M
11			14.7	15.1			L17, LE&M, f?

V mags. for vars. 4-11, Lloyd Evans and Menzies, unpub. (1972). 13 field variables, Laborde and Fourcade.

Laborde and Fourcade, Cordoba Repr 138 (p) (1966); Osborn, Obs 88.26 (p) (1968), Letter (1968); Lloyd Evans, Letter, V3 (1972); Lloyd Evans and Menzies, IAU Coll 21 (1973)

S55b, R62b, FLA66, S69, S70

NGC 5946 α 15^{h}31^m.8, δ −50°30′

1	+178.75	−118.25					F&L 1
2	− 56.37	− 19.25					F&L 2
3	+ 83.87	− 38.50					F&L 4

Five field variables, Fourcade and Laborde.

Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966)

S55b, R62b

NGC 5986 α 15^{h}42^m.8, δ −37°37′

1	+60.0	− 8.3	15.2	16.9			RR?
2	− 8.0	− 2.1	16.1	17.2			RR
3	+23.2	+110.5	16.0	17.0			RR
4	−82.5	+ 18.7	13.6	14.3			Slow
5	+58.6	− 2.8	16.1	17.1			RR

All variables found by Rosino.

Rosino, Asiago Contr 132 (p) (1962)

S55a, R57, S59, S61, R62c, S62, F&L63, S64, FLA66, S69

NGC 6093 (Messier 80) α 16^{h}14^m.1, δ −22°52′

1	−137	+ 49	13.1	14.6	32356.718	16.304	Sp F-G
2	+ 22	− 19	13.7	14.8	34889.704	24.9?	
3	+104	+ 56	15.5	16.15			Short P
4	− 85	+ 61	15.5	16.1			Short P
5	+ 14	− 67	15.4	16.3			Short P
6	+520	+296	12.1	16.1	32741.67	177.90	S Sco, f

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6093 (continued)							
7	+502	+112	11.9	16.3	32770.60	223.50	R Sco, f
Nova	+ 4.0	+ 2.7	6.8		00551		T Sco

Sawyer, Toronto Publ 1, 12 (1942); Joy, ApJ 110.105 (1949); Eggen, Royal Obs Bull 29.E73 (1961); Kukarkin, Letter (1972); Sawyer Hogg and Wehlau, unpub (1972)
Nova bibliography: Sawyer, Toronto Comm 1 (1938)
S55a, S57, R57, S59, S62, R65, St66, S67, S69, S70

NGC 6101 α 16^{h}20^m.0, δ −72°06′

Searched by Fourcade and Laborde, but no variables found.
Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966)
S55b, R62b

NGC 6121 (Messier 4) α 16^{h}20^m.6, δ −26°24′

1	− 281	+ 42	13.46	13.97	30000.08	0.2888545	0
2	− 248	−195	13.05	14.10	30000.03	0.5356832	0
3	− 208	−507	12.92	14.08	38500.16	0.506651	+
4	− 185	−340	11.0	12.5		50-70	Sp G, V
5	− 185	− 93	13.57	13.99	30000.05	0.622398	0
6	− 115	+318	13.54	14.09	30000.27	0.320516	0
7	− 113	+231	12.99	14.28	30000.13	0.4987743	0
8	− 110	+111	12.88	14.22	30000.18	0.508187	+
9	− 104	+105	12.75	14.16	30000.04	0.5718975	0
10	− 68	+159	12.68	14.18	30000.07	0.4907173	0
11	− 64	−297	13.32	14.14	33500.25	0.4930721	−
12	− 53	−207	13.04	14.38	33000.40	0.4461239	−
13	− 47	+270	12.37	13.08		40:	Sp G-K, V
14	− 47	−244	12.96	14.40	32500.35	0.4635338	+
15	− 32	+436	12.98	14.25	27500.35	0.4437857	−
16	− 29	+ 69	13.05	14.18	30000.02	0.5425421	0
17	− 8	+ 20	13.40	13.74			
18	+ 4	+ 27	12.84	14.20	30000.14	0.4787924	0
19	+ 11	+358	12.76	14.18	30000.41	0.4678111	0
20	+ 13	− 63	13.24	13.60	30000.27	0.309383	0
21	+ 19	− 4	12.73	14.10	29500.11	0.4719831	+
22	+ 34	+ 80	13.40	13.98	31000.43	0.6029436	+
23	+ 38	− 26	13.26	13.77	30000.02	0.2985502	+
24	+ 49	+ 48	13.12	14.06	31500.53	0.5467797	+
25	+ 70	+ 70	13.08	14.08	30000.25	0.6127346	
26	+ 94	− 72	12.80	14.14	35000.45	0.5412163	−
27	+ 118	+255	12.90	14.09	30000.52	0.6120191	0
28	+ 259	+ 84	12.60	14.02	31000.05	0.5223405	−
29	+ 326	+598	12.88	14.02	34000.19	0.5224824	−
30	+ 340	− 69	13.29	13.87	31000.12	0.2697490	−
31	+ 353	+ 45	12.72	14.03	31000.18	0.5053039	−

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks

NGC 6121 (continued)

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
32	+ 746	− 40	12.98	13.96	30000.21	0.5791092	0
33	+ 805	+630	12.70	13.96	30000.39	0.6148303	0
34	− 820	+416	13.16	14.36	29723.338	0.554843	
35	− 377	+ 62	13.44	14.15	29705.441	0.627042	
36	− 208	−259	13.26	14.18	29676.370	0.541310	
37	− 39	+ 2	13.46	13.76	29522.064	0.247352	
38	− 23	+ 49	13.38	14.09	29496.053	0.577848	
39	+ 1	− 80	13.62	14.06	29676.463	0.623980	
40	+ 25	+ 49				0.40151	
41	+ 65	−150	13.53	13.97	29676.402	0.2517311	
42	+ 377	+558	13.33	13.78	29526.164	0.303708	
43	+1263	+332	12.92	13.48	29748.245	0.320637	

Joy, ApJ **110**.105 (1949); Hoffmeister, Sonn Veröff 6, 1 (1963); Wilkens, La Plata Bol 7.14 (1964), MVS 2.101 (1964); Oosterhoff and Walraven, BAN 18.387 (1966); Ponsen and Oosterhoff, BAN Suppl 1.3 (1966); Eggen, ApJ 172.639 (1972)
S55a, S57, S59, S61, R62a, S62, S64, L65, R65, S67, C&S69, S69, S70

NGC 6139 α 16^{h}24^m.3, δ −38°44′

Observed by Fourcade and Laborde. No variables found.
Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966)
S55b, R62b

NGC 6144 α 16^{h}24^m.2, δ −25°56′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+481	−117	15.3	16.3			

Sawyer, JRASC 47.229 (1953)
S55a, S57, S59, S62, S69

NGC 6171 (Messier 107) α 16^{h}29^m.7, δ −12°57′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	− 112.8	−522.0	14.0	17.0	40504.	332	V720 Oph, V, f
2	+ 148.8	−388.8	15.6	16.4	40389.502	0.5710205	
3	− 224.4	−183.6	15.55	16.25	40389.595	0.566343	
4	− 99.6	−156.6	15.5	16.15	40389.628	0.2821317	
5	+ 231.0	−161.4	15.7	16.25	40389.709	0.70238	+
6	− 10.8	− 67.2	15.7	16.25	40389.740	0.2602558	
7	+ 42.0	− 61.2	15.6	16.55	40389.696	0.499728	+
8	+ 12.0	− 42.0	15.4	16.45	40389.957	0.559921	−
9	− 26.4	− 19.8	15.95	16.35	40389.583	0.3206025	+ ?
10	− 57.0	+ 8.4	15.4	16.6	40389.532	0.4155329	+
11	+ 9.6	+ 33.0	15.8	16.45	40389.611	0.592835	− ?
12	+ 58.8	+ 61.2	15.25	16.5	40389.593	0.4729722	−
13	− 27.0	+ 72.0	15.35	16.6	40389.596	0.466797	
14	+ 17.4	+ 82.2	15.4	16.5	40389.763	0.4816129	+
15	+ 19.2	+120.0	15.6	16.25	40389.687	0.2885895	

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6171 (continued)							
16	− 67.2	+113.4	15.65	16.5	40389.853	0.5228709	–
17	− 99.0	+ 71.4	15.4	16.45	40389.761	0.561154	
18	+ 77.4	+215.4	15.75	16.5	40389.898	0.564378	
19	+ 232.8	+162.6	15.75	16.3	40389.822?	0.2787622	
20	+ 31.2	+ 51.0	15.65	16.4	40389.653	0.578113	
21	+ 81.0	−144.6	16.3	16.6	40389.704	0.258125	
22	−1354.2	−183.0					prob f
23	− 263.4	+ 19.2	15.5	16.2	40389.725	0.3233436	
24	0.0	+ 8.4	15.65	16.45	40389.615	0.3462153	
25			14.8			red	SK217, L&M

Kukarkin, AC 216.17 (1960); van Agt, BAN 508.327 (1961); Kukarkin, VS 13.384 (1961); Mannino, Bologna Pubbl 7, 18 (1961); Kurochkin, VS 14.15 (1962); Kukarkin, VS 14.21 (1962); Coutts, Master's Thesis, Toronto (1964); Kurochkin, VS 15.164 (1964); Sandage and Katem, ApJ 139.1088 (1964); Sturch, ApJ 148.477, Abs. AJ 72.321 (1967); Dickens, ApJ Suppl 22.249 (1970); Coutts and Sawyer Hogg, Toronto Publ 3.61, Abs. AAS Bull 3.242 (1971); Dickens, Letter, VI (1972); Lloyd Evans, Letter, V25 (1972); Lloyd Evans and Menzies. IAU Coll 21 (1973)

S55a, S57, S59, S61, R62a, S62, S64, L65, R65, S67, S69, S70, F72

NGC 6205 (Messier 13) α 16^{h}39^m.9, δ +36°33′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+ 73.06	− 24.86	13.6	15.1	39691.720	1.458997	Sp A-F, V, mem
2	− 54.10	− 3.04	12.8	14.3	39672.177	5.110939	+, Sp, V, mem
3	−127.70	+ 16.52	15.58	15.79	prob not var		
4	− 47.34	+ 58.18	15.04	15.23	prob not var		
5	+ 71.62	− 14.06	14.33	14.94	40046.7820	0.38177	
6	+ 92.68	+ 76.60	14.0	15.1	39664.923	2.112867	Sp F, V, mem
7	− 39.78	− 82.72	14.72	15.17			f
8	− 93.02	+ 11.29	14.2	15.6	39679.821	0.7503158	mem
9	+ 71.62	− 14.06	14.0	15.1	40038.8121	0.39265	
10	− 5.40	− 70.73	13.1	14.0		SR	Sp, V, mem
11	− 45.78	− 75.88	12.9	13.8		92.5	Sp, V, mem
12	−105.88	+ 53.46	15.0	15.35	prob not var		
13	− 45.37	− 31.30	14.26	14.50	prob not var		
14	+ 3.18	+207.64	16.16	16.45	prob not var		
15	+ 79.03	−115.34	13.32	13.67		irr	mem
16	+349.40	+207.90					Tsoo Yu-hua

Variable 16 = Savedoff A 18, probably Ludendorff 1113.
One field variable, Tsoo Yu-hua.

Joy, ApJ 110.105 (1949); Arp, AJ 60.1 (1955); Brown, ApJ 122.146 (1955); Savedoff, AJ 61. 254 (1956); Wallerstein, ApJ 127.583 (1958); Kraft, Camp and Hughes, ApJ 130.90 (1959); Kurochkin, VS 13.248 (1961); Arp, La Plata Symp p. 87 (1962); Tsoo Yu-hua, Letter (p) (1964); Kadla, Pulk Mitt (Isw) 24.93 (1966); Osborn, Letter (1968), AJ 74.108 (1969), IBVS 350 (1969); Demers, AJ 76.445 (1971); Osborn, Letter (1972)

S55a, S57, S59, S61, R62a, S62, P64, S64, L65, R65, S67, S69, S70

NGC 6218 (Messier 12) α 16^{h}44^m.6, δ −01°52′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+34	−62	11.9	13.2	27306.708	15.508	Sp F-G, V

Sawyer, Toronto Publ 1, 2 (1938); Joy, ApJ 110.105 (1949)
S55a, S57, S59, R62a, S62, R65, S69

NGC 6229 α 16^{h}45^m.6, δ +47°37′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	− 24.6	−105.5	16.78	17.94	35630.542	0.5856908	
2	− 71.9	+ 4.9	16.95	17.93	35631.521	0.5552380	
3	−195.7	+ 41.3	17.21	17.82			
4	− 56.8	− 14.3	17.36:	17.89			
5	+ 14.5	+ 44.1	17.25	17.95	35633.555	0.5336051	
6	+ 44.1	+ 41.5	17.28:	17.96	27953.930	0.559385	
7	− 41.7	− 49.9	16.84	18.01	27978.840	0.506980	
8	− 4.1	− 42.1	15.47	16.51	35573.461	14.845093	Cep
9	− 38.9	+ 38.3	17.08	17.88	35629.516	0.5428497	
10	− 29.5	+ 72.7	17.20	18.00	35629.535	0.5547785	
11	+ 23.9	− 25.0	]17.44	18.01			
12	+ 34.2	− 23.6	17.12	18.02			
13	+140.2	+ 61.3	17.20	17.96	35630.552	0.5473432	
14	− 15.5	− 50.7	16.76	17.86	35631.565	0.4659161	
15	+ 34.2	+ 27.5	17.39	17.92	35611.460	0.2713783	
16	+ 47.0	− 24.2	17.31	17.94	35637.500	0.322784	
17	− 96.3	− 75.0	17.08	17.72	27979.830	0.324880	
18	− 36.1	+ 32.2	17.34	18.00			
19	+ 53.4	− 44.4	16.96	18.00	35629.546	0.4759609	
20	− 27.5	− 36.1	16.91	18.05	35631.524	0.4659728	
21	+117.3	− 61.6	17.12	17.94			
22	+ 4	− 7	15.2	16.3			prob slow

For variables with periods by both Mannino and Mayer, those of Mannino are tabulated because they are based on more observations.

Baade, ApJ 102.17 (p) (1945); Sawyer, JRASC 47.229 (1953); Mannino, Bologna Pubbl 7, 13 (1960); Mayer, BAC 12.167 (1961)

S55a, S57, S59, R62a, S62, S64, L65, R65, S69

NGC 6235 α 16^{h}50^m.4, δ −22°06′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	−16	+ 39	16.5	17.2			
2	+58	−211	16.5	17.3			

Sawyer, JRASC 47.229 (p) (1953)
S55a, S57, S59, S62, S69

NGC 6254 (Messier 10) α 16^{h}54^m.5, δ −04°02′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+ 5	+ 22	13.2	13.8			Sp G, V
2	+ 30	+120	11.91	13.34	34907.0	18.728	Sp F-G, V

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6254 (continued)							
3	−209	+106	13.10	13.82	34905.64	7.908	Min
4							Voroshilov Arp IV-37

Joy, ApJ 110.105 (1948); Arp, AJ 60.1,320 (1955), AJ 62.129 (1957); Wallerstein, ApJ 127.583 (1958); Voroshilov, AC 623.7 (1971)
S55a, S57, S59, R62a, S62, R65, S69

Palomar 15 α 16^{h}57^m.6, δ −00°28′

No variables found.
Kinman and Rosino, ASP 74.499 (1962)
R61

NGC 6266 (Messier 62) α 16^{h}58^m.1, δ −30°03′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+ 41.0	+ 6.1					
2	− 26.6	− 68.9					Sp F-G
3	− 88.9	− 6.8			33421.41	0.49158	
4	− 93.9	− 39.3	15.68	16.85	33419.49	0.54113	
5	−163.2	+123.5	15.50	16.53	33417.51	0.46049	
6	− 81.7	+ 34.0			33419.30	0.49191	
7	+ 22.1	+169.4	15.86	17.06	33419.38	0.56389	
8	− 93.2	+162.4			33423.44	0.53200	
9	− 92.6	+213.1	15.40	16.68	33423.48	0.55662	
10	−454.0	+157.7	15.58	16.93	33418.45	0.53259	
11	−457.1	+126.7	16.06	16.85	33421.56	0.59823	
12	−204.4	+268.9			33421.39	0.48799	
13	+ 1.6	+ 30.2					
14	− 92.2	+265.8	15.27	16.83	33421.41	0.44216	
15	+123.0	+303.4	16.01	16.91	33423.60	0.63024	
16	− 74.5	+ 93.9	15.35	16.51	33421.55	0.59591	
17	− 22.1	+102.4			33423.51	0.5251	
18	− 33.3	+ 92.3	15.90	16.80	33423.58	0.52616	
19	− 14.5	+ 65.5			33421.53	0.52271	
20	+131.6	+159.4	15.68	17.00	33423.52	0.47201	
21	+105.9	+ 79.7	15.75	17.14	33421.42	0.45045	
22	+ 61.9	+ 11.9			33421.48	0.49925	
23	− 73.2	− 37.4			33417.56	0.44821	
24	+ 58.1	− 38.6			33417.59	0.52267	
25	+152.5	− 72.8	16.35	17.71	33421.45	0.44584	
26	−182.9	−303.1					
27	− 6.8	− 59.8			33423.40	0.44916	Vars. 27-42
28	+154.0	+ 19.3	16.81	17.45	33423.52	0.49749	discovered by
29	+153.4	+ 14.5	15.96	17.35	33423.44	0.56	van Agt
30	− 61.7	−181.9	16.69	17.36	33418.54	0.30440	
31	− 46.4	−143.0			33419.37	0.48500	
32	− 1.0	−136.4			33423.51	0.5468	

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6266 (continued)							
33	− 13.7	−117.9	16.79	17.71	33422.51	0.57438	
34	− 61.0	− 4.9			33422.54	0.58372	
35	−113.2	+ 14.1	15.56	16.82	33418.48	0.5288	
36	− 41.2	+125.6	15.84	16.66	33423.49	0.6530	
37	− 53.2	+ 6.5			33423.38	0.5852	
38	− 22.1	− 44.8			33421.56	0.77083	
39	−121.4	+ 59.0	16.02	16.89	33421.51	0.64020	
40	−122.0	+ 45.6			33423.52	0.30131	
41	−118.4	+ 40.7			33423.46	0.55848	
42	−130.0	+ 50.0	16.00	16.35	33421.56	0.24765	
43	− 62.8	−223.1	16.36	17.40	33423.37	0.56356	Vars. 43-82
44	− 47.6	−122.7	16.48	17.99	33423.54	0.44575	discovered by
45	+ 59.0	−187.7	16.72	17.95	33417.60	0.51688	Oosterhoff
46	+130.9	+477.9	16.65	17.63	33418.45	0.53874	
47	− 22.0	+241.6	16.34	16.93	33422.39	0.61211	
48	− 86.1	−130.8	16.35	17.29	33421.49	0.74360	
49	+139.0	−104.7			33423.35	0.54360	
50	+281.7	− 34.4	16.38	17.65	33421.56	0.50264	
51	+294.3	+193.7	16.40	17.01	33421.50	0.26181	
52	+ 75.9	−181.5	16.58	17.87	33423.59	0.50538	
53	−111.8	−101.0					
54	−150.5	−671.7			33423.51	0.38591	
55	+422.7	+278.4	16.07	17.11	33417.50	0.47872	
56	+ 37.1	+118.9	16.22	17.00	33423.47	0.5654	
57	+ 51.1	+121.1	16.00	17.03	33423.61	0.55636	
58	− 98.6	+ 32.2			33423.40	0.48100	
59	+122.1	+ 94.1	16.15	17.23	33421.46	0.57931	
60	+308.8	+395.5	15.99	16.53	33423.63	0.28662	
61	+215.9	+190.7	16.57	17.25	33421.48	0.26602	
62	+238.5	+104.9	15.99	17.26	33419.45	0.54807	
63	+105.4	−102.4	16.75	17.55	33418.59	0.64313	
64	−124.6	−266.4	16.10	17.08	33422.37	0.47299	
65	− 86.6	+137.5					
66	−316.8	+ 17.5	16.19	16.74	33423.60	0.33383	
67	+399.1	+621.4	16.12	17.14	33421.44	0.56488	
68	+146.5	+417.6	16.05	16.57	33419.50	0.23529	
69	+122.3	+109.9	16.39	16.94	33423.55	0.31369	
70	−725.2	− 86.9			33423.55	0.54546	
71	− 87.6	−482.4			33422.34	0.70452	
72	−182.7	−104.5	16.09	17.29	33421.43	0.46751	
73	−203.5	−105.5					
74	− 21.4	− 53.6			33423.60	0.46646	
75	+396.5	+237.5	16.57	17.10	33423.43	0.33429	
76	+178.1	+629.6	15.81	16.55	33421.50	0.61523	
77	+275.3	+ 33.1	16.82	17.30			
78	+338.4	+174.1	16.78	17.45	33421.49	0.62170	
79	+694.3	− 81.0			33423.40	0.31896	

No.	x''	y''	Max.	Min.	Epoch	Period	Remarks
NGC 6266 (continued)							
80	− 85.3	+ 90.4	15.90	16.74	33422.54	0.58858	
81	−110.5	+ 97.3	15.65	16.95	33419.39	0.53093	
82	− 39.4	− 68.0			33421.58	0.56481	
83	− 38.3	− 9.9					van Agt
84			16.55	17.53			G&F
85			16.68	17.55			G&F
86			16.38	17.69			G&F
87			15.80	16.70			G&F
88			16.04	16.75			G&F
89			16.45	17.66			G&F

Wallerstein, ApJ **127**.583 (1958); van Agt and Oosterhoff, Leiden Ann **21**.253 (p) (1959); Gascoigne and Ford, Proc Astr Soc Aust **1**.16 (1967); van Agt, Priv comm (1971); Gascoigne, Letter (1971)

S55a, S57, S59, S61, R62a, S62, R65, FLA66, S69, S70

NGC 6273 (Messier 19) α 16^{h}59^m.5, δ −26° 11′

1	+ 4	+ 48	14.1	15.1			
2	+14	+123	13.4	14.7			Cep?
3	−28	− 6	14.2	15.2			
4	− 2	− 24	15.1	15.7			

Two field variables, Sawyer.

Sawyer, Toronto Publ **1**, 14 (p) (1943)

S55a, S57, S59, S61, R62a, S62, S69

NGC 6284 α 17^{h}01^m.5, δ −24°41′

1	− 24	+ 36	15.6	16.1			
2	− 47	− 17	16.1	17.0			
3	− 28	− 13	15.3	15.7			
4	+ 22	− 18	15.4	16.3			
5	+109	−205	16.4	17.0			
6	+139	+221	15.9	16.4			

Four field variables, Sawyer.

Sawyer, Toronto Publ **1**, 14 (p) (1943)

S55a, S59, S62, S69

NGC 6287 α 17^{h}02^m.1, δ −22° 38′

1	−152	−40	16.2	17.1			
2	+ 46	−26	15.7	15.9			
3	+ 26	+44	16.1	16.8			

Three field variables, Sawyer.

Sawyer, Toronto Publ **1**, 14 (p) (1943)

S55a, S59, S62, S69

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks

NGC 6293 α 17^{h}07^m.1, δ −26° 30′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+ 81.0	+49.5	15.9	16.6			
2	−135.6	+64.5	15.8	16.7			
3	+ 48.6	+18.6	15.5	15.8			
4	+ 92	−81	16.1	17.1			
5	+ 78	−83	15.7	16.5			

Three field variables, Sawyer.
Shapley, Mt Wils Contr 190 (1920); Sawyer, Toronto Publ 1, 14 (p) (1943)
S55a, S59, S62, S69

NGC 6304 α 17^{h}11^m.4, δ −29° 24′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+102.0	−114.4	16.5	18.0			
2	−168.9	+169.6	15.7	17.5			RR?
3	+200.5	+ 60.2	16.5	17.5			RR
4	−272.4	−154.9	16.0	16.9			
5	+235.5	− 7.8	16.7	17.6			RR
6	+304.7	−191.7	16.6	17.8			RR
7	+ 0.8	−293.5	17.5	18.3			
8	+486.7	+ 49.9	16.7	17.7			RR
9	+587.1	+230.2	16.8	17.8			RR
10	−591.2	−247.6	16.2	17.9			RR
11	−244.8	−534.6	16.4	17.2			
12			13.95	14.30			Terzan 28
13			11.00	12.52			Terzan 29
14			10.75	13.25			Terzan 30
15			12.90	13.88			Terzan 32
16			13.70	13.80			Terzan 33
17			15.25	15.40			Terzan 40
18			13.60	[14.60			Terzan 43
19			13.38	13.78			Terzan 68
20			13.91	14.15			Terzan 69
21			13.87	14.40			Terzan 72

Vars. 1-11 found by Rosino, 12-21 by Terzan on red plates. Many field variables by Terzan.
Rosino, Asiago Contr 132 (p) (1962); Terzan, Haute Prov Publ 9, 1 (1966), Haute Prov Publ 9, 24 (1968)
S55b, R57, S61, R62c, S62, F&L63, S64, FLA66, S69, S70

NGC 6316 α 17^{h}13^m.4, δ −28° 05′

S55b, R62b

NGC 6325 α 17^{h}15^m.0, δ −23° 42′

S55b, R62b

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6333 (Messier 9) α 17^{h}16^m.2, δ −18°28′							
1	+ 91	− 76	15.6	16.9	29427.886	0.585727	
2	+ 40	− 31	15.6	16.4	29436.854	0.628191	
3	+207	−210	15.7	16.85	32000.735	0.605397	
4	+ 23	− 35	15.8	16.95	30520.749	0.670076	
5	+ 34	− 7	16.0	16.8	29435.870	0.274708	
6	− 70	− 14	15.7	16.95	29435.870	0.607795	
7	−111	− 80	15.95	17.2	29434.860	0.628456	
8	− 73	− 99	16.05	16.9			
9	+334	−191	16.0	16.75	30933.704	0.322990	
10	+ 37	+ 26	16.2	16.9	30553.653	0.242322	
11	− 4	− 7	15.7	16.8			
12	−275	−136	15.85	16.95	29408.951	0.571784	
13	+259	+ 11	16.7	17.8	30554.694	0.47985	f

Sawyer, Toronto Publ 1, 24 (p) (1951)
S55a, S59, R62a, S62, L65, R65, S69

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6341 (Messier 92) α 17^{h}15^m.6, δ +43°12′							
1	+127.5	+ 41.3	14.35	15.30	24410.198	0.7028015	
2	+ 91.2	+ 69.2	14.55	15.25	24409.347	0.6438829	Bℓ
3	+ 53.7	+252.7	14.20	15.35	24410.377	0.6375010	[illegible], Sp
4	− 76.0	+ 58.0	14.45	15.20	24433.262	0.6289128	
5	+ 81.6	− 53.7	14.50	15.25	24428.315	0.6196963	Bℓ
6	+ 38.7	+ 43.3	14.53	15.40	27340.360	0.600001	
7	+ 1.6	− 50.5	14.45	15.70	37871.517	0.5149114	
8	+208.9	+208.0	14.50	15.20	24410.289	0.6732769	Sp, Bℓ
9	+ 18.0	− 48.1	14.80	15.60		0.61 var	
10	+ 83.0	+ 36.3	14.75	15.20	24410.454	0.3773182	
11	+ 71.2	− 67.1	14.80	15.20	24466.213	0.3084409	Bℓ
12	− 29.9	− 97.8	14.70	15.10	38905.364	0.409939	
13	+153.4	− 60.1					
14	−316.0	+245.7	14.45	14.85	39026.410	0.346178	EW, f
15	− 2	+ 77	14.05	14.55			RR

V15 in Second Catalogue is same as V12 (Kukarkin, Letter, 1972) so V16 renumbered 15. Nine field variables, Mnatsakanian and Sahakian.

Walker, AJ 60.197 (1955); Preston, ApJ 134.651 (1961); Kheylo, IBVS 43 (1964), IBVS 104 (1965), Voprosy Astrofiziki, Kiev, p.124 (1966), VS 16.213 (1967); Sturch, AJ 72.321, ApJ 148.477 (1967); Bartolini, Battistini and Nasi, Bologna Pubbl 9, 15 (1968); Mnatsakanian and Sahakian, AC 528.5 (1969); Eggen, ApJ 172.639 (1972); Kukarkin, AC 707.7 (c) (1972)

S55a, S57, S59, S61, R62a, S62, P64, S64, L65, R65, St66, S67, C&S69, S69, S70

NGC 6342 α 17^{h}18^m.2, δ −19°32′

S55b, R62b

No.	x"	y"	Max.	Min.	Epoch	Period	Remarks

NGC 6352 α $17^h21^m.6$, δ −48°26′

1	+226.33	−158.13					F&L 1
2	+130.63	+ 58.30					F&L 4, f?
3	−286.00	+139.91					F&L 8
4			12.7	13.4			HH 113

Fourcade and Laborde nos. 2, 3, 5, 6, 7, 9-12 considered field. V4 found by Lloyd Evans and Menzies (1973), who also have one field variable.

Fourcade and Laborde, Cordoba Repr 117 (1964), Cordoba Repr 126 (1965); Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966); Hartwick and Hesser, ApJ **175**.77 (1972); Lloyd Evans, Letter (1972); Lloyd Evans and Menzies, IAU Coll 21 (1973)

S55b, R62b, F&L63, S67, S69

NGC 6355 α $17^h20^m.9$, δ −26°19′

S55b, R62b

NGC 6356 α $17^h20^m.7$, δ −17°46′

1	− 15	− 24	16.3	17.2			
2	+101	−110	16.8	17.1			
3	− 24	+ 45	16.0	[17.5			
4	+187	+ 47	15.9	[17.5	32328.	208:	
5	255	+152	15.7	[17.5			
6*	575	+114	15.6	[17.3			
7			15.4V	15.6V			SW 34
8			15.6V	16.0V			SW 72
9			15.3V	15.7V			SW 30
10			15.4V	15.7V			SW 46

*Formerly Sawyer 1 1, which Wilkens says should be included in the cluster. Vars. 7-10 discovered by Lloyd Evans and Menzies (unpub).

Sawyer, JRASC 47.229 (p) (1953); Sandage and Wallerstein, ApJ **131**.598 (p) (1960); Lloyd Evans, Letter (1972); Sawyer Hogg, unpub (1972); Wilkens, Letter (1972); Lloyd Evans and Menzies, IAU Coll 21 (1973)

S55a, S57, S59, R62c, S62, P64, R65, S69, F72

NGC 6362 α $17^h26^m.6$, δ 67°01′

1	00	00					
2	26	100					
3	83	90					
4	− 79	88					
5	+ 81	− 15					
6	− 54	+174	14.9	15.3	36565.999	0.2628878	VH 15
7	+ 22	+104	13.7	14.5	36565.724	0.5215674	VH 6
8	263	+108	14.8	15.3	36566.080	0.3810811	VH 17
9	207	+138					

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6362 (continued)							
10	+186	+353	14.5	14.9	36566.024	0.3617240	VH 10
11	− 29	+ 48					
12	−246	−103	14.5	15.5	36565.817	0.5328711	VH 3
13	−234	−120	14.4	15.4	36565.811	0.5800254	VH 1
14	+369	+ 28	15.0	15.3	36565.865	0.2463744	VH 16
15	+ 49	00					
16	+ 16	−270	14.2	15.5	36565.939	0.5256730	VH 4
17	+201	− 68	14.9	15.3	36566.026	0.3149808	VH W1
18	+110	+ 72	14.2	15.2	36566.074	0.5128892	VH 13
19	+123	− 25					
20	+ 45	− 15					
21	+160	−108					
22	+182	−313	14.8	15.3	36566.058	0.3639867	VH 14
23	+ 30	− 23					
24	+ 71	− 36					
25	−356	−212	14.0	15.5	36566.150	0.4558950	VH 2
26	+ 22	− 38					
27	−193*	+384	14.7	15.4	36566.061	0.3860821	VH 9
28	+ 24	+ 37					
29	− 15	− 35					
30	− 89	+ 74	14.2	15.4	36566.162	0.6133787	VH 5
31	− 33	+ 80					
32	+ 40	+ 31					L&F
33	+316	+364	14.7	15.3	36566.028	0.4412499	VH 11

*Coordinate corrected.

Vars. 16-31 found by van Agt (1961) seven of them independently by Van Hoof. One field variable, 58′ from centre, Shapley.

Shapley, HB 777 (1922); van Agt, BAN 508.329 (1961); Van Hoof, Louv Publ 14, 131 (1961); Rosino and Sawyer Hogg, IAU Trans 11B.301 (1962); Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966); Laborde and Fourcade, Cordoba Repr 138 (1966); van Agt, Priv comm (1971)

S55a, S59, R62c, S62, F&L63, S64, L65, R65, S69

NGC 6366 α 17^{h}25^m.1, δ −05°02′

No.	x″	y″	Max.	Min.
1	− 26	− 42	15.5	17.0
2	+305	−390	15.7	16.8

Sawyer, Toronto Publ 1, 5 (p) (1940)

S55a, S59, S62, S69, S70

Haute Provence 1 α 17^{h}28^m.5, δ −29°57′

No.	Remarks
1	T248, 1964
2	T249, 1964
3	T361, 1965
4	T362, 1965

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
HP 1 (continued)							
5							T363, 1965
6							T364, 1965
7							T126, 1966
8							T130, 1966
9							T247, 1966
10							T251, 1966
11							T136, 1966
12							T137, 1966
13							T139, 1966
14							T142, 1966
15							T143, 1966

Identification of new variables only on prints, as indicated.

Cailliatte, Lyon Publ **5**, 33 (1962), Haute Prov Publ **7**, 2 (1964); Terzan, Haute Prov Publ **7**, 3, 38 (p) (1964), Haute Prov Publ **8**, 11 (p), 12 (1965), Haute Prov Publ **8**, 12 bis (p) (1966)

R62b, S67, S69

NGC 6380 α 17^{h}31^m.9, δ −39°02′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	−14.85	+131.45					F&L

Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966)

S55b, R62b

NGC 6388 α 17^{h}32^m.6, δ −44°43′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1							V1, M
2							V2, M
3							V3
4							V4, M
5							V6
6							V7
7							V8
8							V10
9							V11

All variables found by Lloyd Evans and Menzies, identified on print.

Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966); Feast, Quart JRAS 13.191 (1972); Lloyd Evans and Menzies, IAU Coll 21 (c) (1973)

S55b, R62b, F72

Tonantzintla 2 α 17^{h}32^m.7, δ −38°32′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+71.78	+63.25					F&L
2	+80.85	+49.50					F&L

Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966)

No.	x"	y"	Max.	Min.	Epoch	Period	Remarks
NGC 6397 α 17h36m.8, δ −53°39′							
1	+210.7	+448.4	12.73	17.53	13727.6	314.6	Sp, M, V, f
2	−279.0	−424.6	14.30	15.24		45 or 60?	prob f
3	−220.0	− 33.5	15.51	16.65	33119.320	0.330667	f

Bamberg var. 866 in environs.

Swope and Greenbaum, AJ 57.83 (1952); Woolley, Alexander, Mather and Epps, Royal Obs Bull 43 (1961); Feast, Obs 86.120 (1966); Strohmeier. Bauernfeind and Ott, Bamb Veröff 6.9 (1966); Swope, Letter (1969)

S55a, S57, S59, A62, S62, P64, S64, R65, FLA66, S67, S69

No.	x"	y"	Max.	Min.	Epoch	Period	Remarks
NGC 6401 α 17h35m.6, δ −23°53′							
1			14.8r	15.2r			T&R 41
2			15.9r	16.5r			T&R 157
3			15.2r	15.9r			T&R 164

Terzan and Rutily have more than a hundred field variables.

Terzan and Rutily, Astr and Ap 16.408 (p) (1972), IAU Coll 21 (1973)

S55b, R62b

No.	x"	y"	Max.	Min.	Epoch	Period	Remarks
NGC 6402 (Messier 14) α 17h35m.0, δ −03°13′							
1	+ 17	+ 47	14.65	16.1	38191.8	18.734	−, Sp G, V
2	−116	−119	15.8	17.0	38198.58	2.794708	Sp F, V
3	− 3	− 90	16.65	17.55	38199.823	0.522455	−
4	+169	+ 73	17.2	18.6	38199.23	0.651313	
5	−136	+ 90	17.1	18.7	38199.61	0.548796	
6	+ 34	− 77	15.8	16.4			
7	+ 62	− 97	15.4	16.5	38189.56	13.603	+, Sp F-G, V
8	+ 96	+ 35	17.8	18.6	38199.496	0.686071	
9	+151	− 39	17.0	18.4	38199.47	0.538831	
10	− 51	−205	17.1	18.5	38199.34	0.585914	
11	+196	−223	16.4	18.0	38199.59	0.604417	
12	+224	−177	17.1	18.6	38199.918	0.503952	
13	− 29	−118	17.0	18.6	38199.690	0.535215	+
14	+ 54	+ 1	17.2	18.1	38199.931	0.471857	
15	−135	+147	16.9	18.6	38199.51	0.557727	
16	− 79	− 36	16.8	18.2	38199.40	0.600617	
17	−228	+122	15.5	16.15	38204.72	12.085	+, Sp, V, f?
18	+ 61	− 22	16.9	18.15	38199.885	0.479065	−
19	−128	+ 2	17.0	18.6	38199.34	0.545671	
20	−145	+ 98	17.9	18.55	38198.734	0.263721	
21	+ 72	+125	16.3	17.4			
22	+ 70	+ 95	17.3	18.5	38199.23	0.655916	
23	+ 74	+281	17.1	18.5	38199.72	0.552342	
24	− 2	+ 75	17.0	18.7	38199.64	0.519901	
25	− 28	−312	17.65	18.4	38199.48	0.360707	
26	− 85	+ 27	16.5	17.5			
27	−421	+151	16.45	17.6	34936	308.0	f?

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6402 (continued)							
28	−465	+372	15.0	16.0			E, f?
29	− 68	−152	15.7	16.2			
30	+ 76	− 12	16.9	18.3	38199.72	0.534226	
31	− 41	+ 32	16.8	17.7	38199.383	0.619636	
32	+ 36	+147	17.0	18.1	38199.55	0.655975	
33	−138	+ 12	17.3	18.3	38199.59	0.479946	
34	− 70	+ 26	17.8	18.8	38199.854	0.606627	+
35	−112	− 49	16.2	17.4			
36	+204	−346	17.2	18.3	38199.33	0.677990	
37	+ 5	+ 18	17.65	18.9	38199.654	0.489060	
38	+ 11	− 17	16.0	17.0			
39	+ 46	− 2	16.1	17.6			
40	+253	+310	16.4	17.1			
41	− 13	− 3	16.0	17.1			
42	+ 36	+ 12	15.9	17.1			
43	+ 68	+ 23	17.0	18.2	38199.46	0.521747	
44	+ 20	+116	16.3	17.5			
45	− 90	+ 94	15.7	16.4			
46	+ 91	− 66	16.4	17.4			
47	− 89	+ 26	16.5	17.6			
48	− 4	+ 40	16.3	17.7			
49	− 98	− 19	16.0	16.9			
50	− 15	− 38	16.1	17.0			
51	+104	−305	17.6	18.15	38198.709	0.367606	
52	+ 82	+ 39	16.5	17.0			
53	+134	+129	16.4	17.3			
54	+121	+113	16.6	17.6			
55	+ 33	+106	16.5	17.5			
56	− 68	−184	16.4	17.4			
57	+134	−116	16.3	17.6			
58	−123	− 34	16.4	17.3			
59	− 32	+ 30	17.4	18.75	38199.561	0.555634	
60	+ 41	+ 54	16.2	17.7			
61	+ 12	− 43	16.6	17.7	38199.610	0.569824	
62	−232	−154	18.0	18.5	38235.444	0.638460	
63	+122	− 63	16.5	17.4			
64	− 51	−169	16.5	17.5			
65	−125	+ 13	16.4	17.2			
66	−133	+ 37	16.6	17.4			
67	+ 34	+ 14	16.1	17.5			
68	+ 10	− 19	17.1	18.7	38199.958	0.507217	
69	+140	+ 26	16.6	17.3			
70	+ 43	− 23	16.0	17.2			
71	−116	− 50	17.05	18.3	38199.602	0.525925	
72	+122	−119	16.5	17.5			
73	+ 05	+ 07	16.5	18.0		irr?	
74	+ 07	+ 91	16.5	17.2		irr?	
75	+ 35	− 12	16.7	18.5	38199.737	0.545281	

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6402 (continued)							
76	105	+ 03	16.1	17.0	38199.466	1.89003	
77	110	+ 55	17.55	18.10			
78	−137	− 5	17.50	18.50			
79	12	18	17.40	18.50			
80	35	145	17.50	18.45			
81	38	138	17.65	18.10			
82	79	−122	17.65	18.20			
83	− 65	34	17.70	18 50			
84	44	− 38	17.80	18.60			
85	21	+ 48	17.65	18.25			
86	+ 64	+ 22	17.85	18.75			
87	74	+ 11	17.60	18.60			
88	− 78	+ 10	17.55	18.55			
Nova	+ 30	+ 04	16		29071		Only on plates of 1938

Vars. 73-77 and Nova, Sawyer Hogg and Wehlau; 77-88, Wehlau and Potts.

Joy, ApJ 110.105 (1949); Sawyer Hogg and Wehlau, AJ 69.141, Toronto Comm 97 (p) (1964); Rep, Sky Tel 27.147 (p) (1964); Sawyer Hogg and Wehlau, AJ 70.678 (1965), Toronto Publ 2, 17 (1966), Toronto Publ 2, 19 (1968); Demers and Wehlau, AJ 76.916 (1971); Wehlau and Sawyer Hogg, unpub (1972); Wehlau and Potts, unpub (1972)

S55a, S57, S59, S61, R62a, S64, R65, S67, C&S69, S69, S70

Palomar 6 α 17^{h}40^m.6, δ 26°12′

28 variables found in environs by Terzan, who says none is a probable cluster member.

Terzan, Haute Prov Publ 9, 1 (1966), Priv comm (1969)

S70

NGC 6426 α 17^{h}42^m.4, δ +03°12′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	170	+ 44	17.30	18.25	35638.528	0.61784	
2	204	53	17.60	18.10	35638.475	0.35545	Alt P 0.262
3	94	33	17.10	17.50	35660.484	0.40385	
4	− 77	− 74	17.70	18.15	35640.468	0.42586	
5	68	22	17.25	18.15	35638.460	0.70906	
6	46	+ 52	17.30	18.25	35638.449	0.68197	
7	+ 10	− 4	17.4:	18.1:			RRa?
8	− 15	− 53	17.4:	18.2:			RRa?
9	39	85	17.55	18.05	35638.460	0.29009	
10	+ 46	+ 11	17.55	18.05	35638.430	0.36503	
11	+285	− 7	15.40	16.30	35638.506	0.46164	V979 Oph, f
12	+ 33	2	17.60	18.00	35640.550	0.23679	Alt P 0.191
13	+137	215	17.20	18.10	35634.437	0.65190	

Three field variables also.

Boyce and Hurahata, HA 109.19 (1942) (HV 11037); Grubissich, Asiago Contr 94 (p) (1958)

S55a, S59, S61, S62, L65, R65, S69

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks

NGC 6440 α 17^{h}45^m.9, δ −20°21′

S55b, R62b

NGC 6441 α 17^{h}46^m.8, δ −37°02′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+ 46.20	− 44.83					
2	+ 36.85	+ 23.93					
3	+350.63	− 90.75					
4	+ 58.85	−176					
5	+206.25	+225.50					
6	+ 30.53	+ 48.68					
7	− 38.50	+485.10					f?
8	−243.10	−444.68					f?
9	− 27.50	− 47.30					
10	+ 74.25	− 60.50					

All variables found by Fourcade and Laborde.
Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966)
S55b, R62b

NGC 6453 α 17^{h}48^m.0, δ −34°37′

Observed by Fourcade and Laborde. No variables found.
Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966)
S55b, R62b

NGC 6496 α 17^{h}55^m.5, δ −44° 15′

Observed by Fourcade and Laborde. No variables found.
Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966)
S55b, R62b

NGC 6517 α 17^{h}59^m.1, δ −08°57′

S55b, R62c

NGC 6522 α 18^{h}00^m.4, δ −30°02′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	−67.5	+34.4	17.08	17.74	32416.672	0.270	G222, mem
2	+ 0.5	+39.7	16.79	17.77	32740.861	0.47398	G133
3	+14.7	+37.2	17.24	17.74	32705.874	0.289	G44, mem
4	+25.6	+ 8.3	17.27	18.59	32387.747	0.563826	G170, mem?
5	+66.0	−42.6	17.41	18.19	32349.871	0.28684	G37, mem
6	+96.5	+30.5	17.77	18.23	32416.753	0.192392	G247, mem?
7	−51.5	+62.7	17.02	17.61		irr	G172, f
8	−20.2	+49.6	15.76	17.00	32290.987	1.747	G27, f
9	−19.5	−64.9	16.73	17.23	32740.786	0.299	G232, f?
10			17.70 mean			0.564	Clube 7, mem

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks

NGC 6522 (continued)

G numbers those assigned by Baade and Gaposchkin. Clube's var. 7 identified on Plate 2 (1965) where some other numbers do not correspond with text. Membership comments from Clube (1972).

Gaposchkin, VS 10.337 (p) (1955); Nassau, Spec Vat Ric 5.171 (1958); Woolley, Report of the Astronomer Royal (1964); Alexander, Obs 80.110 (1965); Clube, Royal Obs Bull 95.E383 (p) (1965); Terzan, Haute Prov Publ 8, 12 (p) (1965); Clube, Letter (1972); Kukarkin, Letter (1972)

S55a, S59, S61, R62a, S62, P64, L65, R65, FLA66, S67, S69, F72

NGC 6528 α 18^{h}01^m.6, δ –30°04′

A few variables from rich galactic field projected against this cluster, but Baade considered none of them a cluster member. S55a.

Gaposchkin, VS 10.337 (1955)

S59, S61, R62a, S62, FLA 66, S69

NGC 6535 α 18^{h}01^m.3, δ –00°18′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	–197	+65	16.3	17.3			

Sawyer, JRASC 47.229 (p) (1953)

S55a, S57, S59, R62c, S62, S69

NGC 6539 α 18^{h}02^m.1, δ –07°35′

One unpublished variable, Baade. S55a.

S57, S59, R62c, S62, S69

NGC 6541 α 18^{h}04^m.4, δ –43°44′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	–18.0	–126.0	12.5	[16		long	Alcaino 127, prob mem

Alcaino, Astr and Ap 13.399 (1971)

S55a, S57, S59, R62c, S62, F&L63, FLA66, S69

NGC 6544 α 18^{h}04^m.3, δ –25°01′

R62b

NGC 6553 α 18^{h}06^m.3, δ –25°56′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+186	+ 20				0.5642	
2	+ 75	–152				0.5818	prob f
3	– 23	– 38				0.4886	
4	+ 16	– 2				270:	M
5	– 71	– 12				]100	
6							LE&M A1
7							LE&M A2

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6553 (continued)							
8							LE&M 3
9							LE&M 6
10							LE&M 7
11							LE&M 13
12							LE&M 14
13							LE&M 24
14							LE&M 33
Nova	−131:	−281:	8	[12	30955		N Sgr 1943

Vars. 1-5 found by Thackeray, 6-14 and one suspected by Lloyd Evans and Menzies (1973). Shapley's two suspected variables are doubtful, Thackeray, Letter (1956).

Lloyd Evans and Menzies, IAU Coll 21 (p) (1973). Nova: Mayall, AJ 54.191 (1949)

S55a, R57, S59, R62a, S62, R65, St66, S69

NGC 6558 α 18^{h}07^m.0, δ −31°47′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	− 24.9	− 3.2	16.1	17.5		RR	Rosino
2	− 15.6	+ 46.6	15.0	15.8			Rosino
3	+ 52.1	+ 32.2	16.2	17.5		RR	Rosino
4	− 55.5	− 24.2	16.6	17.7		RR	Rosino
5	− 48.1	+124.7	17.0	17.6		RR?	Rosino
6	− 23.3	− 50.2	16.8	17.5			Rosino
7	+113.5	+132.4	14.4	15.4			Rosino
8	− 2.2	−183.6	16.3	17.4		RR	Rosino
9	−339.2	− 36.6	16.3	17.8			Rosino

Fourteen variables in field, Rosino.

Rosino, Asiago Contr 52 (1954), Asiago Contr 132 (p) (1962)

S55b, S57, R57, S59, S61, R62c, S62, S64, FLA66, S69

IC 1276 α 18^{h}08^m.0, δ −07°14′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+ 86.9	+115.0	]20.2	22		SR?	SH
2	− 15.2	+ 23.7	18.9	20.0	37468.96	0.548	K&R
3	+ 74.2	− 51.4	17.8	22		SR?	K&R
4	+ 41.7	+136.1	18.8	19.5		SR?	K&R
5	−204.4	+230.3	18.8	19.6		SR?	K&R

Sawyer Hogg, JRASC 53.97 (p) (1959); Kinman and Rosino, ASP 74.501 (1962); Rosino and Sawyer Hogg, IAU Trans 11B.301 (1962)

S55b, S57, S62, S64, S69

NGC 6569 α 18^{h}10^m.4, δ −31°50′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	− 95.1	+ 28.9	17.3	18.1			Rosino
2	− 91.9	+ 0.3	17.0	18.0		short	Rosino
3	+ 43.7	+ 12.4	16.6	17.5		slow	Rosino
4	+116.5	+202.1	15.3	17.3			Rosino
5	− 20.7	− 2.5	17.0	17.8			Rosino

NGC 6569 (continued)

Three field variables Rosino.
Rosino, Asiago Contr 132 (p) (1962)
S55b, R57, S61, R62c, F&L63, S64, FLA66, S69

NGC 6584 α 18^{h}14^m.6, δ −52°14′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	−82.5	24.75					F&L

Nine field variables, Bailey
Bailey, HB 801 (1924): Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966)
S55a, S59, R62c, S62, F&L63 S69

NGC 6624 α 18^{h}20^m.5, δ −30°23′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+167.75	+176.00					F&L 1
2	+114.13	+226.88					F&L 2
3	− 9.63	+ 49.50					F&L 11
4	− 39.88	− 20.63					F&L 14

Only four of the variables in FLA 66 are listed here. The other 29 are considered field stars.
Laborde and Fourcade, Cordoba Repr 127 (p) (1966): Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966)
S55b, R62b, S67, S69

NGC 6626 (Messier 28) α 18^{h}21^m.5, δ −24°54′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+174.0	+188.5	15.1	16.4			
2	− 47.3	+ 63.1	14.3	14.8			
3	− 32.9	+111.0	14.6	15.4			
4	− 34.5	+ 33.6	13.6	14.8	32759.765	12.937	Sp F-G
5	− 44.8	+ 16.4	14.8	15.6	36040.674	0.644360	
6	+ 34.1	+ 50.4	14.3	15.2			
7	+172.2	+102.7	15.9	17.0			
8	+227.3	−222.3	15.6	16.6	25474.346	0.56600	Hoff 63c
9	−158.6	−252.4	14.75	15.7	35696.652	1.965	Alt 0.6627
10	+ 96	− 79	13.5	14.6			
11	− 14	+ 35	15.0	16.3			
12	+148	− 49	15.0	16.1	35373.660	0.578254	
13	− 92	− 24	15.1	16.7	34893.807	0.504027	
14	−131	−100	15.6	16.1		0.330918	
15	−472	−186	15.8	17.0			
16	+432	−372	15.9	17.0	36067.656	0.5220278	
17			12.8	14.8	38620	92.8	RV, Hoff 63a
18			15.4	16.6	28022.400	0.5782670	+, Hoff 63b

Joy, ApJ 110.105 (1949); Sawyer, AJ 54.193 (1949); Hoffleit, AJ 70.307 (1965); Deery, AAVSO Abstr Oct. p. 3 (1968); Hoffleit, IBVS 312 (1968), IBVS 387 (1969), IBVS 660 (1972); Sawyer Hogg and Moorhead, unpub (1972)
S55a, S57, S59, S62, S67, S69, S70

NGC 6637 (Messier 69) $\alpha\ 18^h28^m.1$, $\delta\ 32°23'$

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	− 20	− 9	13.0	15.0			red, mem
2	−228.8	+201.3	15.9	17.3			RR, f
3	− 36.6	− 78.5	14.6	15.8			red, mem
4	− 17.5	− 90.7	14.3	17.2	28433	196	mem
5	+ 8	+ 7	13.0	14.5		195	mem
6							II 37, red
7							III 43, red
8							IV 11, red

Vars. 1, 2, 3, 5 found by Rosino. V5 is Rosino 10, V4 is Ponson V1894. Rosino considers his variables 5-9 as field stars. Wilkens (Letter) suggests they may be cluster members. Identifications of new vars. 6-8, Lloyd Evans and Menzies (1973) from Hartwick and Sandage (1968).

Ponson, Leiden Ann 20.431 (Star 69) (1957); Rosino, Asiago Contr 132 (p) (1962); Hartwick and Sandage, ApJ 153.715 (p) (1968); Catchpole, Feast and Menzies, Obs 90.63 (1970); Lloyd Evans and Menzies, Obs 91.35 (1971); Wilkens, Letter (1972); Lloyd Evans and Menzies, IAU Coll 21 (1973)

S55b, S57, R57, S61, R62c, F&L63, S64, R65, FLA66, S69, S70, F72

NGC 6638 $\alpha\ 18^h27^m.9$, $\delta\ -25°32'$

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1							Terzan 9
2							Terzan 10
3							Terzan 11

Terzan's new variables identified on print. Six unpublished variables, Sawyer Hogg and Terzan (1972).

Terzan, Haute Prov Publ 9, 24 (p) (1968)

S55b, S57, R62b, S70

NGC 6642 $\alpha\ 18^h28^m.4$, $\delta\ -23°30'$

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1			14.5	16.0			Hoff 145a, M
2			14.9	16.0			Hoff 145b

Two field variables, Hoffleit 137a and 137b.
Hoffleit, IBVS 660 (c) (1972)
S55b, R62b

NGC 6652 $\alpha\ 18^h32^m.5$, $\delta\ -33°02'$

Observed by Fourcade and Laborde, 1966; no variables found.
Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966)
S55b, R62b

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6656 (Messier 22) α 18^{h}33^m.3, δ −23°58′							
1	− 54.0	− 10.0	14.2	15.4	36070.678	0.615543	
2	+ 158.6	+ 69.2	13.45	14.25	37113.784	0.641717	
3	+ 214.7	+420.2	15.4	16.6	40063.702	0.515485	f
4	− 4.0	− 68.0	13.9	15.1	40058.727	0.716393	
5	− 178.2	− 33.8	12.5	13.4	40027.818	92.6	Sp G, V, mem
6	− 74.4	−100.0	13.65	14.5	35279.755	0.638548	
7	− 342.4	+411.2	13.65	15.0	35279.755	0.649520	
8	− 39.5	− 64.8	12.0	13.0		irr.	Sp G, V, mem
9	− 211.2	− 35.0	12.8	13.8	32740.781	87.71	Sp G, V, mem
10	− 39.0	−125.0	13.75	14.7	36069.643	0.646018	
11	− 14.4	+ 14.0	13.1	13.9	36073.656	1.69049	Sp, V, mem
12	+ 0.8	− 77.8	14.2	14.6	Prob. not var.		
13	+ 76.4	+158.9	13.9	14.85	35309.730	0.672523	
14	+ 250.8	+486.4	14.5	17.5	34983.6	199.7	Sp M, V, f
15	+ 115.3	− 83.2	14.25	14.75	35279.755	0.373248	
16	+ 185.0	− 17.8	14.25	14.85	35335.645	0.325348	
17	− 438.0	+126.0	15.3	16.7	35338.7	113.2	f?
18	− 86	+433	14.3	14.7	34927.766	0.324960	
19	− 33	+130	14.3	14.8	35313.669	0.384009	
20	− 120	−123	13.9	14.6	34927.766	0.430060	
21	+ 36	+ 88	14.0	14.5	34922.732	0.327530	
22	−1089	+213	14.1	15.8	34927.766	0.6245374	
23	− 5	− 14	13.9	14.65	35341.635	0.355195	+
24	− 26	+ 10	14.4	15.5			
25	+ 326	+375	14.35	14.85	32006.740	0.402367	+
26			15.6	17.6	36051.7	309.0	Hoff 8, 181a, f?
27			14.0	15.1	35280.720	0.342811	Hoff 10, 181b, f?
28			13.8	14.8	34920.7	424.5	Hoff 16, 173a, f?
29			14.5	15.3			Hoff 187b
30			12.8	13.4			Hoff 191
31			12.8	13.5			Hoff 185
32	− 631	−331	15.4	18.0	34932.7	233.35	Watt, f?
33	− 149	−794	14.4	17.0	35308.8	250.3	Watt, f?

Sawyer, Toronto Publ 1, 15 (p) (1944); Joy, ApJ 110.105 (1949); Hoffleit, AJ 69.301 (1964), Sky Tel 27.274 (1964), AJ 70.307 (1965), AJ 72.711 (1967); Eggen, ApJ 172.639 (1972); Hoffleit, IBVS 660 (c) (1972); Sawyer Hogg and Wehlau, unpub (1972)

S55a, S57, S59, R62a, S62, L65, R65, S67, S69, S70

NGC 6681 (Messier 70) α 18^{h}40^m.0, δ −32°21′							
1	+ 46.1	−113.0	16.2	17.2		RR?	Rosino 1
2	−104.5	−581.3	16.1	17.1		RR?	Rosino 3

Four field variables, Rosino (1962).

Rosino, Asiago Contr 132 (p) (1962)

S55b, S61, R62c, F&L63, S64, FLA66, S69

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6712 α 18^{h}50^m.3, δ −08°47′							
1	− 63	− 17	16.18	17.32	35284.988	0.512030	
2	+ 69	+ 15	14.70	16.00	35007.4	104.6	AP Sct, mem
3	− 28	− 93	16.66	17.34	35285.235	0.655680	
4	+179	− 27	16.96	17.62	35285.082	0.611741	
5	+ 67	− 71	16.00	17.40	35285.350	0.545390	
6	+ 18	− 41	16.10	17.62	35285.344	0.510849	
7	−129	− 18	13.10	18.20	35327	190.48	CH Sct, V, mem
8	+ 24	+ 60	14.55	16.20	35400	117.0	
9	− 4	+285	16.80	19:			UG?, f
10	− 99	+ 30	15.45	15.95	35287	174	
11	−116	−333	16.7	17.5			E, f
12	+ 29	+ 39	16.00	17.54	35285.298	0.502776	
13	− 93	+ 25	15.98	17.36	35285.193	0.562651	Ros, San
14	−426	+ 31	15.30	17.90	35690.5	202.2	Sawyer F1
15	+247	− 38	15.60	16.60		100?	Har 160
16	−138	+175	16.8	17.5			Har 141, E
17	+ 27	+ 49	15.5				Har 151
18	− 25	− 1	16.64	17.26	35285.123	0.345044	Sandage
19	− 13	+ 34	16.50	16.92	35285.162	0.423900	Sandage
20	+ 1	+ 9	16.60	17.14	35285.031	0.330870	Sandage
21			13.5	13.8			LE&M

Sawyer, JRASC 47.229 (1953); Harwood, Priv comm (1956), Leiden Ann 21.387 (1962); Smith, Sandage, Lynden-Bell and Norton, AJ 68.293 (1963); Rosino, Bamb Kl Veröff **4**, 40.202 (1965); Sandage, Smith and Norton, ApJ **144**.894 (1966); Rosino, ApJ **144**.903 (1966); Feast, Obs 87.35 (1967); Lloyd Evans, Letter (1972); Lloyd Evans and Menzies, IAU Coll 21 (1973)

S55a, S57, S59, S61, R62a, S62, S64, R65, S67, S69, F72

NGC 6715 (Messier 54) α 18^{h}52^m.0, δ −30°32′							
1	+ 83	+ 10	15.8	16.9	35661.45	1.34956	Cep
2	− 6	+ 90	16.3	17.3	35635.60	0.5111	
3	− 14	+ 179	16.5	17.6	35630.44	0.5010	
4	− 38	+ 311	16.6	17.8	35630.40	0.4803	
5	− 129	+ 45	16.5	17.8	35636.34	0.5780	
6	+ 194	− 188	16.6	17.8	35630.50	0.5417	
7	+ 54	− 165	16.6	17.5		0.46?	RR
8	+ 365	− 330	15.7	16.7			E? f?
9	− 67	− 637	16.8	17.7			RR
10	+ 115	− 530	16.9	17.6			RR?
11	− 106	−1086					f
12	− 220	− 248	15.4	16.4	35630.64	0.3220	prob f
13	− 238	+ 451	16.5	17.5			RR
14	+ 240	+ 213	16.2	17.4	35630.44	0.6892	
15	+ 124	− 63	16.6	17.5	35639.64	0.5869	
16	+ 87	− 917					f
17	+ 697	− 435	16.6	17.6	35665.30	0.4660?	

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6715 (continued)							
18	+ 511	+ 382	16.5	17.2			RR?
19	−1260	− 190					f
20	+ 106	+ 95	16.8	17.2			
21	+ 85	− 231		17.8	var?		
22	− 21	− 167	16.4	16.7			
23	+ 362	+ 170	16.8	17.6	35638.60	0.5286	
24	+ 453	+ 55	16.5:		var?		
25	− 65	+ 74	15.4	17.2	35628	101±	SR
26	+ 201	− 159	16.8	17.4			RR?
27	+ 209	− 306	16.75 med				
28	+ 68	+ 161	16.3	17.6	35630.45	0.5128	
29	− 134	− 43	16.6	17.7	35638.44	0.5893	
30	+ 2	+ 80	16.6	17.7			RR
31	− 104	− 66	16.8	17.7			RR
32	− 181	+ 69	16.5	17.7	35636.36	0.5210	
33	+ 72	− 112	16.3	17.5	35629.58	0.4922	
34	− 61	− 153	16.4	17.6	35636.32	0.5053	
35	− 83	+ 54	16.6	17.6	35665.36	0.5266	
36	+ 129	+ 51	16.5	17.6	35629.58	0.5977	
37	+ 41	− 44	17.3	17.9			
38	− 69	+ 37	17.1	17.8			
39	− 105	− 63	16.7	17.7			RRa
40	− 56	− 112	16.5	17.5	35630.44	0.586	
41	+ 128	+ 45	16.4	17.6	35630.45	0.6187	
42	+ 70	+ 57	16.8	17.8			RR
43	− 154	+ 54	16.8	17.5	35630.44	0.3913	
44	+ 10	− 81	16.6	17.8			RRa
45	+ 117	− 109	16.25	17.6	35630.62	0.4889	
46	− 38	− 39	17	17.8?			
47	− 29	+ 96	16.7	17.7	35635.60	0.5069	
48	+ 254	− 47	16.7	17.6	35635.58	0.6849	
49	− 101	− 134	16.8	17.4			RR
50	+ 104	+ 61	16.7	17.5	35630.64	0.5635	
51	+ 222	+ 208	16.85	17.55			RR?
52	+ 90	− 50	16.85	17.55			RR
53	− 66	− 76	16.8?	17.6			RR
54	− 113	+ 327	16.5	17.6	35629.57	0.5713	
55	+ 146	− 205	16.6	17.6	35629.58	0.4259	
56	− 336	− 124	16.65	17.4			RRc
57	+ 293	− 31	16.7	17.7		0.64?	RRa
58	+ 80	+ 282	16.5	17.5	35630.50	0.6148	
59	− 218	− 254	16.8	17.75	35630.63	0.5993	
60	− 269	− 247	16.8	17.6	35629.57	0.570?	RR
61	− 43	+ 107	17.05	17.85			RR
62	− 92	+ 102	17.0	17.8			RRc?
63	− 40	− 133	16.9	17.6			RR
64	+ 259	− 498	16.7	17.5			SR

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6715 (continued)							
65	+ 243	+ 165	16.25	17.05	35638.36	0.4481	f
66	+ 234	+ 207	15.6	17.1			SR
67	0	+ 69	16.85	17.55			RR
68	− 643	+ 337	16.8	17.7	35630.65	0.5414	
69	− 328	+ 283	16.45	17.25			RR?
70	+ 128	− 426	16.8	17.4			RR
71	− 32	+ 106	14.8	16.2		77:	SR
72	− 61	+ 149	15.6	16.7			E?
73	+ 26	+ 62	17.0	17.5			
74	+ 113	− 141	16.7	17.5			RR
75	+ 18	+ 79	16.5	17.7	35638.36	0.5797	
76	− 106	− 22	16.5?	17.5?			RR
77	− 112	− 42	16.5	17.5			RR
78	+ 73	− 13					
79	+ 30	− 46	16.9	17.5			RR?
80	+ 51	− 25	16.7?	17.5			
81	+ 45	+ 12					
82	− 49	− 46	16.7?	17.5?			

Vars. 29-82 found by Rosino and Nobili.
Rosino and Nobili, Asiago Contr 97 (p) (1959)
S55a, R57, S57, S59, S61, R62a, S62, L65, R65, FLA66, S69

NGC 6717 α 18^{h}52^m.1, δ −22°47′

S55b, S61

NGC 6723 α 18^{h}56^m.2, δ −36°42′

1	+ 75.1	−199.5	15.76	16.25	38993.793	0.538177
2	+135.7	− 78.3	14.71	16.47	38993.951	0.503539
3	−244.4	+ 7.5	14.78	16.57	38994.131	0.494097
4	+ 16.8	+ 77.4	14.55	15.90	38993.855	0.451060
5	− 4.7	+ 51.0	15.20	16.00		0.57264
6	+ 7.2	+ 48.3	14.90	16.05	23618.80	0.4814
7	+197.5	− 71.3	15.53	16.14	38994.037	0.307672
8	+ 15.9	+ 10.8	14.75	15.60		0.53
9	+ 74.0	+ 15.7	14.70	15.80	38994.101	0.575803
10	+148.6	+ 83.9	15.39	16.03	38993.996	0.252325
11	+133.3	+228.8	14.85	15.65	38993.922	0.534283
12	+ 43.2	− 45.7	14.95	15.85	23618.53	0.4694
13	− 46.2	− 71.3	14.69	16.22	38993.930	0.507867
14	+ 38.2	− 43.2	14.95	15.80	23618.91	0.6190
15	− 93.4	+167.5	14.72	16.43	38993.847	0.435439
16	− 46.5	+ 93.3	14.55	15.69	38994.104	0.696273
17	+ 43.1	−102.5	15.27	16.66	38994.135	0.530179
18	−137.8	− 18.2	15.40	16.27	38994.091	0.526455
19	−169.4	−112.5	15.24	16.63	38994.018	0.534111

NGC 6723 (continued)

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
20	+ 3.5	+ 39.9				0.49293	F&L
21	− 79.0	− 28.2	14.50	15.72	38993.760	0.594863	
22	− 70.8	+ 38.1	15.18	15.72	38994.19	0.30844	
23	+ 53.4	− 10.0			38994.08	0.6259	
24	+117.5	−112.0	15.50	16.11	38993.999	0.300143	
25	+ 98.6	+203.1	12.1V	13.0V		SR?	
26	−197.0	+155.9	12.2V	13.1V		SR?	
27	−219.1	+101.6	15.50	16.33	38994.093	0.619249	
28	+ 10.8	− 79.0				0.4863	
29	+ 12.4	+ 63.6				0.53:	

New coordinates for all variables, Menzies (1973), who discovered vars. 21-29.

Innes, UOC 37.300 (UY Cr A) (1917); Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966); Menzies, Proc Astr Soc Aust 1.16 (1967), Doctoral Thesis, Australian Nat'l Univ (1967); Lloyd Evans, Letter (1972); Lloyd Evans and Menzies, IAU Coll 21 (1973); Menzies, IAU Coll 21 (1973)

S55a, S59, S62, L65, R65, S69

NGC 6752 α 19ʰ06ᵐ.4, δ −60°04′

1	+236.5	+143.0					F&L
2	+ 44.0	+ 82.5					F&L

V1 considered the same as that mentioned in S55a.

Fourcade, Laborde and Albarracin, Atlas y Catalogo, Cordoba (1966); Eggen, ApJ 172.639 (1972)

S55a, S57, S59, R62c, S62, F&L63, S69

NGC 6760 α 19ʰ08ᵐ.6, δ +00°57′

1	+57	− 57	15.7	17.0			
2	− 6	−100	16.7	17.2			
3	+31	− 10	15.5	[17.4			
4	+42	+ 39	15.4	[17.5			

Taffara has new eclipsing variable in field, and gives periods for it and two other field eclipsers.

Sawyer Hogg, IAU Agenda and Draft Reports, p. 560 (1967); Taffara, SA1 43.481 (1972)

S55a, S57, S59, R62a, S62, S69

NGC 6779 (Messier 56) α 19ʰ14ᵐ.6, δ +30°05′

1	+ 44.69	+ 74.10	15.0	16.2	30899.341	1.510019	Cep, Sp, V, mem
2	+ 18.16	+ 33.09	15.1	15.6		SR	
3	+ 25.10	+ 91.69	14.4	15.1		SR	Sp, V, mem
4	−112.13	−159.46	15.9	16.4			
5	+ 6.79	−134.78	14.4	15.2		SR	
6	− 2.02	+ 37.06	12.9	14.8	30172.7	90.02	RV, Sp, V, mem
7	+293.48	−213.24	15.6	16.3		irr	

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6779 (continued)							
8	− 97.63	−335.90	15.9	16.7		SR	
9	+177	+525	15.6	16.1		SR	
10	−431.53	+ 88.33	16.4	17.4	30967.473	0.5988948	RR, f?
11	−415.58	+283.80	15.5	16.3	34239.516	0.0756252	RRs, f?
12	−243.96	− 95.41	15.6	16.4			

Field variables found by Kurochkin, 20 (1968), 21 (1970), 30 (1971).

Joy, ApJ **110**.105 (1949); Sawyer, JRASC 43.38 (1949); Balázs, Budapest Mitt 30 (1952); Rosino, Asiago Contr 117 (1961); Preston, Krzeminski and Smak, ApJ 137.401 (p) (1963); Barbon, Asiago Contr 175 (p) (1965); Kurochkin, VS **16**.460 (c) (1968), VS 17.186 (c) (1970), VS 17.620 (c) (1971)

S55a, S57, S59, R62a, S62, S64, R65, S67, S69, S70

Palomar 10 α 19^{h}16^m.0, δ +18°28′

V1 found by Rosino (1972) on red plates, centre of cluster, large amplitude.

Rosino, Letter (1972)

R61, S61

NGC 6809 (Messier 55) α 19^{h}36^m.9, δ −31°03′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+304.2	− 55.6			32413.39	0.57997286	
2	−214.9	− 26.0			32467.18	0.4061601	
3	+ 78	−304			32413.22	0.6619023	
4	+108	+ 59			32413.34	0.3841702	
5	− 41	− 74				0.2?	
6	+111	− 20			32413.32	0.388904	

Bailey, HA **38**.243 (p) (1902); King, HB 920 (1951)

S55a, S57, S59, S61, R62a, S62, R65, FLA66, S69

Palomar 11 α 19^{h}42^m.6, δ −08°09′

No variables found. Abell suggests this may be very rich open cluster.

Kinman and Rosino, ASP **74**.499 (1962)

R61, S61

NGC 6838 (Messier 71) α 19^{h}51^m.5, δ +18°39′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+140	+ 24	13.5	14.9		193	Z Sge, SR
2	+ 44	−146	13.8	14.7			Slow
3	+ 44	− 70	15.2	17.0	33481.78	3.7907	E, Min, mem
4	+266	+ 31	14.7	15.3			RR?

Silbernagel, AN **192**.450 (1912); Sawyer, JRASC 47.229 (1953); Prochazka, Letter (1967); Hartwick, Priv comm (1972); Kukarkin, Letter (1972); Sawyer, unpub (1972)

S55a, S57, S59, S61, R62a, S62, P64, R65, St66, S69

NGC 6864 (Messier 75) α 20^{h}03^m.2, δ −22°04′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+ 15.6	−83.4					
2	− 9.0	+54.0					
3	+ 18.0	+85.5					
4	− 18.0	−84.6					
5	+108.0	−36.0					
6	+ 8.4	−81.0					
7	− 24.6	+78 0					
8	− 13.5	−41.4					
9	+ 45.6	−24.0					
*10	− 43.5	+50.4					
11	+121.2	+84.0					
12	+ 39.6	+75.0					

*Suspected. Four additional suspected variables, numbered 13-16, are omitted.
Shapley, Mt Wils Contr 190 (p) (1920)
S55a, S57, R57, S59, S61, S62, S64, S69, S70

NGC 6934 α 20^{h}31^m.7, δ +07°14′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	− 45	− 39	16.5	17.7	27307.968	0.568099	
2	− 40	− 14	16.4	17.9	27658.930	0.48195	+
3	0	+ 58	16.6	17.8	27275.882	0.539806	
4	+ 39	+ 58	16.3	17.8	27275.882	0.616422	
5	+ 59	+221	16.7	17.8	26923.943	0.564560	
6	− 27	− 33	16.7	18.0	27275.941	0.5558418	
7	+ 92	+ 59	16.65	17.7	28038.833	0.644049	
8	+100	+ 50	16.75	17.5	27715.760	0.623989	
9	+ 63	+ 18	16.5	17.8	27308.844	0.549156	
10	−135	+ 72	16.4	17.8	27275.882	0.519959	−
11	+ 17	+ 28	17.1	18.15			
12	+ 29	− 44	16.3	17.4	27309.955	0.464215	
13	− 47	+ 25	16.55	17.8	26915.956	0.551334	
14	− 7	− 90	16.5	17.8	27659.902	0.52199	
15	+ 10	− 53	15.65	16.3			not RR
16	+ 36	+ 18	16.7	17.9	26915.956	0.604853	
17	− 73	−107	16.7	17.9	27309.955	0.598272	
18	+ 49	− 8	16.6	17.7			RR
19	+ 30	+ 1	16.4	17.9	21515.710	0.480550	
20	− 26	+ 17	16.5	17.6	27307.886	0.548225	
21	− 35	− 3	16.6	18.15			RR
22	−240	−173	16.5	17.8			RR
23	− 31	− 16	16.85	18.05			RR
24	+ 37	− 53	16.8	17.95			RR
25	+ 50	+ 37	16.5	17.9	27275.795	0.509086	−
26	+ 31	−196	16.9	17.8			RR
27	−148	+180	16.7	17.8	27272.914	0.592204	
28	−234	+100	16.3	17.8	27715.760	0.485151	+

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6934 (continued)							
29	− 85	−183	16.4	17.8	26628.689	0.454818	
30	+161	+127	16.6	17.65	27714.745	0.589853	
31	+146	−101	16.5	17.8	21481.825	0.505070	
32	− 10	+ 51	16.4	17.7	21481.825	0.511948	
33	+ 37	+ 12	16.5	17.7	27309.920	0.518445	
34	− 21	+ 16	16.6	18.05			RR
35	+157	−142	16.6	17.85	27664.870	0.544222	
36	+ 10	− 35	16.05	17.55			RR
37	+ 23	+ 10	16.5	17.95			RR
38	+ 12	− 18	16.6	18.0	21543.702	0.523562	
39	+ 8	− 16	16.6	17.95			
40	− 8	+ 26	16.15	16.8			RR
41	+ 30	− 39	16.6	17.9	27275.882	0.520404	
42	+ 55	+ 20	16.5	17.9	27659.975	0.524251	
43	+ 21	+ 27	16.4	17.4			
44	− 43	− 30	17.0	17.9	26925.933	0.630384	
45	− 32	− 9	16.3	17.8			
46	+ 14	− 24	16.9	18.05			
47	+ 10	− 26	16.8	17.95			RR
48	+ 33	+ 52	16.5	18.05			RR
49	+ 13	− 55	16.7	17.95			RR
50	+ 15	− 37	16.9	17.95			
51	+ 7	− 25	15.85	16.6			RR

Sawyer, Toronto Publ 7, 5 (p) (1938); Sawyer Hogg and Wehlau, unpub (1972); Harris, AJ 78, in press (1973)

S55a, S57, S59, S61, S62, S64, R65, S67, S69, S70

NGC 6981 (Messier 72) α 20^{h}50^m.7, δ −12°44′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+ 43.5	− 54.0	16.45	17.25	33129.400	0.619818	
2	+ 99.0	+194.4	16.29	17.95	33126.405	0.46526213	−
3	− 52.5	− 58.5	16.16	17.74	33809.553	0.4976052	−
4	−106.5	+ 37.5	16.56	17.74	33147.462	0.5524863	−
5	− 38.4	− 21.6	16.40	17.43	22163.738	0.4991	
6	+ 78.0	+ 78.6	16.70	17.10			
7	− 3.6	+ 55.5	16.36	17.53	39318.997	0.524630	
8	− 6.6	+ 89.4	16.73	17.74	33145.372	0.5683752	−
9	+ 11.4	+ 50.4	16.73	17.54	39319.660	0.60296	
10	− 48.6	− 73.5	16.69	17.77	33857.504	0.5581814	+
11	+ 57.0	− 36.6	16.81	17.72	39319.478	0.51997	
12	+ 9.0	− 21.6	16.31	17.17	22163.90	0.4111	
13	+ 13.5	+ 17.4	15.77	16.85	39319.330	0.55114	f?
14	− 13.5	+ 36.0	16.40	17.06	22163.90	0.5904	
15	− 64.5	− 21.0	16.63	17.56	39318.917	0.55044	
16	− 4.5	− 19.5	16.31	17.21	39319.490	0.585497	
17	+ 3.6	− 43.5	16.57	17.62	33215.483	0.5735404	+
18	− 26.4	− 37.5	15.70	16.28	22162.88	0.52016	

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 6981 (continued)							
19	+ 3.0	+112.5	17.15	17.30	not var		
20	− 54.6	+ 15.0	16.50	17.40	33857.420	0.595046	
21	− 82.5	+ 12.6	16.56	17.86	33145.370	0.5311636	+
22	−113.4	+ 1.5	17.10	17.25	not var		
23	− 99.0	+116.4	16.95	17.73	39319.437	0.585083	irr
24	− 15.6	− 24.0	16.20	16.55	22161.92	0.4973:	
25	−133.5	+ 67.5	16.92	17.48	33481.810	0.3533739	+
26	− 91.5	− 45.0	16.90	17.20			
27	+209.4	−234.0	16.30	17.78	39319.557	0.673774	f?
28	+ 65.4	+ 81.0	16.83	17.64	33853.437	0.56724873	−
29	+ 36.0	− 52.5	16.68	17.48	39319.295	0.605497	
30	+ 71.4	− 97.5	16.50	16.90			
31	+ 5.4	+ 36.6	16.44	17.36	39319.110	0.53249	
32	−138.0	− 42.0	16.84	17.78	39319.440	0.52834	
33	+ 2.4	− 60.6	16.95	17.25			
34	− 6.0	+ 7.5	16.06	16.73			
35	+231	+ 27	16.78	17.75	39319.772	0.543771	
36	− 12	0	16.0	16.8			
37	+ 7	− 8	15.5	16.5			
38	+ 5	− 9	16.6	17.3			
39	+195	+243	16.8	17.6			
40	+ 18	+ 16	16.4	17.4			
41	− 15	− 20	16.7	17.5			
42	+ 12	+ 3					red

Nobili, Asiago Contr 83 (1957); Dickens and Flinn, MN 158.99 (1972); Dickens, Preprint (p) (1972), Letter, V42 unpub (1972)
S55a, S57, S59, R62a, S62, S64, L65, R65, S67, S69

NGC 7006 α $20^{h}59^{m}.1$, δ +16° 00′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	−177.9	+114.8	18.20	19.60	26918.939	0.492729	
2	− 35.3	− 37.3	18.25	19.50	35453.245	0.586986	
3	− 24.4	+ 34.2	18.55	19.65	27209.945	0.560557	
4	− 21.0	− 41.1	not var				
5	− 20.9	+ 38.4	18.45	19.50	35419.240	0.534713	
6	− 13.5	− 44.5	18.40	19.60	27039.626	0.498030	
7	+ 3.2	− 36.9	not var				
8	+ 34.4	+ 13.5	18.70:	19.50	35342.700	0.608289	
9	+ 39.4	+ 16.6	not var				
10	+ 42.8	− 11.8	18.45	19.80	35403.638	0.542907	
11	+148	+ 50	18.35	19.65	35428.232	0.576036	
12	+122.0	− 64.0	18.35	19.55	35419.410	0.574039	
13	+102.7	+ 40.2	18.30	19.60	35453.274	0.551647	
14	+ 35.3	+128.3	18.35	19.55	35459.269	0.560358	
15	− 11.5	+114.8	18.40	19.50	35429.250	0.588067	
16	− 39.6	+135.5	18.35	19.55	35429.240	0.537582	

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 7006 (continued)							
17	− 99.3	+ 85.5	18.35	19.60	35429.201	0.511494	
18	− 29.6	− 89.5	18.55	19.65	35034.330	0.603706	
19	− 0.6	− 25.3	16.70	17.90	35630.93	92.17	red SR
20	− 21.2	− 24.4	18.70	19.45	35003.270	0.577476	
21	− 21.5	− 18.4	18.60	19.50	34978.700	0.568968	2 Alt Ps
22	− 12.6	− 15.8	18.40	19.60	35727.400	0.526927	
23	− 27.6	− 7.5	18.50	19.60	27274.873	0.608042	
24	− 25.8	− 2.9					blended
25	− 19.2	+ 5.2	18.80	19.60	26975.580	0.532792	
26	− 10.6	− 2.9	18.55	19.60	34978.710	0.607364	Alt 0.540
27	− 11.8	+ 0.3	18.30	19.25	26975.650	0.522321	
28	− 15.8	+ 4.3	18.75	19.60	35657.925	0.560987	Alt 0.5619
29	+ 35.0	+ 31.6	18.40	19.60	27033.640	0.559195	
30	+ 5.2	+ 16.6	18.70	19.70			
31	+ 10.0	+ 11.2	18.65	19.55	26891.945	0.563126	
32	+ 20.9	+ 13.8	18.50	19.50	36376.920	0.585572	
33	+ 31.9	+ 22.4	18.50	19.50	34978.735	0.556812	
34	+ 26.4	+ 9.2	18.75	19.30	prob not var		
35	+ 36.2	− 2.0	18.60	19.55	35419.260	0.596309	P var?
36	+ 25.5	− 3.7	18.75:	19.35	27274.850	0.437847	2 Alt Ps
37	+ 18.9	− 3.4	18.40:	19.45	37274.860	0.567920	blended
38	+ 21.5	− 18.4	18.70	19.50	26919.700	0.608599	Alt 0.622
39	+ 11.5	− 25.3	18.50:	19.55	36426.865	0.577261	Alt 0.565
40	+ 9.7	− 14.3	19.15:	19.60:			not RR
41	+ 1.4	− 11.2	18.70	19.60	34978.725	0.495330	Alt 0.499
42	+ 9.5	− 7.5	18.80:	19.30:			
43	− 4.0	− 28.7	18.75	19.50	26975.650	0.596656	
44	+133.9	−174.0	18.55	19.41	35017.632	0.58779	
45	−190.0	− 74.4	18.70	19.38	35419.398	0.583858	
46	−125.6	− 54.7	18.85	19.31	35719.429	0.666320	Alt P?
47	−183.4	− 22.1	18.60	19.35	35428.253	0.568294	
48	−100.0	+ 90.3	18.70	19.28	35428.240	0.611975	
49	+ 4.8	+ 40.5	18.65	19.60	26891.947	0.581897	
50	− 42.9	− 7.6	18.60	19.45	35034.300	0.590428	
51	+ 54.3	+ 46.0	18.90	19.35	26918.700	0.642709	
52	− 1.0	+ 85.5	18.60	19.34	35419.290	0.621746	
53	+ 47.5	− 9.1	18.75	19.25			
54	+ 3.2	− 30.0	16.95	17.75			red SR
55	−254.4	+304.4	18.40	19.60	35017.663	0.537740	
56	− 10.7	− 11.8	18.75	19.55	36376.920	0.520202	Alt 0.549
57	− 6.2	− 12.1	18.65	19.45	26918.890	0.637235?	
58	+ 14.8	+ 16.2	18.85	19.45	26920.735	0.514982	Alt 0.525
59	+ 26.2	+ 9.6	18.55	19.50	35657.875	0.463454	Alt 0.480
60	− 10.9	+ 7.7	18.85:	19.50			
61	− 36.2	+ 18.8	18.45	19.50	26918.865	0.589141	
62	− 21.6	+ 3.0	18.75	19.55	26975.650	0.495233	
63	+ 14.1	+ 22.2	18.65	19.50	27274.860	0.527996?	

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 7006 (continued)							
64	+ 21.4	+ 6.2	18.80	19.45			
65	− 8.7	+ 9.9	18.70	19.50	36376.920	0.544081	Alt 0.515
66	+ 28.1	− 2.5	18.75	19.50	26918.730	0.617159	Alt 0.603
67	− 14.1	− 1.1	18.85	19.45			
68	+ 12.7	+ 5.8	18.60	19.50			
69	+ 10.0	+ 3.9	18.90:	19.30:			
70	+ 8.7	0.0	18.40	18.85:			
71	− 3.2	− 13.6	18.80	19.40			
72	+ 26.0	− 0.5	18.80	19.40	26919.675	0.2610439	Alt 0.318
73	− 15.5	0.0	18.40	19.30	35456.600	0.577966	
74	+ 1.2	− 10.8	18.40	19.60	27033.635	0.566850	
75	+152.2	−156.7	18.40	19.00:	27300.600	0.518750	

New vars. 44-52 Rosino and Mannino, 53, 54, Sandage and Wildey, 55-75 Rosino and Ciatti.

Sandage, ASP 66.324 (p) (1954); Rosino and Mannino, Asiago Contr 59 (p) (1955); Mannino, Asiago Contr 84 (1957); Rosino and Ciatti, Asiago Contr 199 (p) (1967); Sandage and Wildey, ApJ 150.469 (p) (1967); Pinto, Priv comm (1972)

S55a, S57, S59, S61, R62a, S62, L65, R65, S67, S69, S70

NGC 7078 (Messier 15) $\alpha\ 21^h27^m.6$, $\delta\ +11°57'$

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	−118.6	+ 24.4	14.48	15.52	20724.394	1.437523	+, Sp
2	−171.7	+ 6.0	15.44	16.00	40442.58	0.6842736	
3	−248.0	− 46.8	15.70	16.29	40072.500	0.3887407	
4	−112.6	−163.6	15.58	16.24	40442.553	0.3135758	
5	−100.3	−212.5	15.66	16.24	40442.510	0.3842142	
6	+ 24.4	+ 76.5	14.93	15.68	25900.190	0.6659671	
7	+ 10.1	+ 73.2	15.56	15.98	25900.102	0.3675643	
8	− 0.6	+126.8	15.18	16.01	20725.103	0.6462446	
9	+ 15.6	+138.7	15.18	16.09	20724.993	0.7152819	
10	+125.6	+ 1.7	15.61	16.18	20724.967	0.3863931	
11	+172.3	− 21.8	15.52	16.22	20725.008	0.3432527	
12	+163.0	− 50.7	15.35	16.12	20724.930	0.5928844	Bℓ
13	+126.6	− 68.8	15.25	16.36	20725.068	0.5749536	
14	+ 84.1	−256.2	15.76	16.35	20725.167	0.3820024	
15	+ 81.7	−304.1	15.26	16.50	20724.991	0.5835687	Bℓ
16	+101.9	+129.8	15.50	15.97			
17	+ 83.7	+110.6	15.62	16.17	20725.001	0.4288924	+, Bℓ
18	+ 77.3	+100.4	15.47	16.05	20725.101	0.3677379	
19	+111.3	+160.4	15.11	16.42	20725.038	0.5723030	Bℓ
20	+ 81.2	− 9.8	15.04	16.07	25900.236	0.6969598	
21	+ 34.4	− 57.5	15.25	16.20			
22	−330.8	− 45.8	15.35	16.36	20724.719	0.7201510	
23	+192.0	+256.1	15.53	16.33	20724.891	0.6326959	Sp, Bℓ
24	−106.7	− 6.1	15.38	15.96	25900.534	0.3696955	
25	+302.9	− 10.7	15.49	16.52	20724.674	0.6653286	
26	+ 23.5	+331.9	15.83	16.37	20725.058	0.4022695	−
27	+222.5	+248.2	not var				

NGC 7078 (continued)

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
28	+309.9	+534.2	15.53	16.53	20724.739	0.6706464	
29	+163.3	+212.2	15.52	16.37	20725.128	0.5749761	+
30	−165.0	− 3.4	15.55	16.01	40442.479	0.4059796	B♀
31	−112.6	+245.6	15.74	16.30	20725.044	0.4081781	
32	− 50.4	+107.8	15.01	15.93	25900.589	0.6054003	
33	− 41.2	− 29.4	15.15	15.95	24409.065	0.5839452	
34	− 55.4	− 54.5	prob var				
35	− 34.0	−163.6	15.70	16.32	20725.143	0.3839986	
36	− 27.7	− 81.6	15.12	16.31	25900.141	0.6241424	
37	− 25.2	− 77.4					
38	+ 7.6	−146.2	15.47	16.09	20725.100	0.3752769	
39	+ 20.5	−124.8	15.58	15.98	20725.184	0.3895696	B♀
40	+131.8	−116.7	15.46	16.32	20724.834	0.3773302	
41	+ 62.9	− 55.4	15.50	16.15	24409.010	0.6452282	
42	+227.5	− 36.8	15.68	16.36	20725.086	0.3601745	
43	+416.7	+103.2	15.74	16.40	20725.808	0.3959928	
44	+ 91.3	+ 3.0	15.00	16.02	20725.128	0.5955547	−
45	+ 66.9	− 31.0	15.20	16.15	24409.224	0.6773992	
46	+ 56.0	+ 33.2	15.40	16.32			
47	+ 45.7	− 4.3	15.0	16.2	25900.380	0.602799	
48	+ 59.7	+150.6	15.4	15.9	25900.346	0.3649762	
49	+ 40.3	+166.6	14.83	15.42		0.6552054	
50	+165.0	+100.0	15.52	16.12	25900.173	0.2980583	+
51	+ 6.2	+ 91.4	15.56	16.10	25900.280	0.3969565	
52	+192.4	− 22.6	15.36	16.44	20724.800	0.5756132	+
53	− 92.6	−111.0	15.60	16.07	20725.202	0.4141270	
54	+ 10.8	+ 88.4	15.55	16.05	25900.078	0.3995683	
55	+ 65.3	− 18.8	15.49	16.30			
56	+ 57.4	0.0	15.19	16.11			
57	+ 75.2	− 56.4	15.51	16.06	20724.891	0.3492988	
58	− 55.6	+ 8.8	15.5:	16.10			
59	+ 41.3	+ 41.5	15.10	15.95	24409.520	0.5547922	
60	+ 53.4	− 59.3	15.29	16.00			
61	− 67.3	− 40.2	15.2:	15.8:			
62	− 71.6	+ 39.6	15.3:	15.8:		0.3882:	
63	+ 49.8	+ 31.0	15.54	16.44			
64	− 46.2	+ 19.1	15.5	16.0	25900.211	0.355624	
65	−102.4	− 38.7	15.55	16.05	24409.366	0.7183491:	
66	− 68.4	−112.4	15.61	16.13	20725.179	0.3793488	
67	− 86.6	− 10.4	15.5:	16.2:			
68	− 31.8	+ 12.6					
69	− 37.0	− 25.2					
70	− 34.0	− 19.2					
71	− 34.8	− 12.6					
72	− 2.2	+ 34.8	15.0:	15.8:	24409.042	1.1386:	
73	− 3.7	+ 20.0					
74	+ 36.3	− 85.8	15.45	16.30	24409.188	0.296071	
75	+ 2.2	− 30.3					

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
NGC 7078 (continued)							
76	+ 0.7	− 28.9					
77	− 11.8	− 22.9					
78	− 6.7	+ 47.4	15.15	15.8:	24409.421	0.398879	
79	+ 21.5	− 23.7					
80	− 47.4	− 26.6	15.1:	15.8:			
81	− 21.5	− 5.9					
82	− 20.7	+ 1.5					
83	+ 16.3	− 7.4					
84	+ 18.5	− 16.3					
85	+ 20.7	+ 2.2					
86	+ 12.6	+ 4.4	13.9	14.8	24410.62	17.109	
87	+ 23.7	− 23.7					
88	+ 2.2	+ 26.6					
89	− 23.7	− 6.7					
90	+ 31.1	+ 4.4					
91	+ 67.3	+ 28.9	15.3:	16.0:			
92	+ 9.6	− 25.2					
93	+ 27.4	− 33.3	15.5:	16.0:			
94	+ 3.7	+ 28.9					
95	+ 5.2	− 40.0					
96	+165.6	+215.0	15.85	16.30	24409.242	0.396046	
97	− 79.5	+ 29.3	15.50	16.25	24409.548	0.696333	
98	− 67.1	+ 46.1	15.4:	15.95	24409.07	0.4701:	
99	+ 29.2	+195.4	15.70	16.10	24410.435	0.277995:	
100	+ 12.5	− 35.8	15.5	16.3	24409.058	0.406114	
101	−104	+540	15.75	16.30	24409.292	0.400360	
102	+ 68.8	+ 31.5	15.70	16.15	24409.119	0.7589:	
103	−251.5	−273.3	15.7	16.4	36070.16	0.368126	
104	−151.6	−642.5	15.6	16.4	36070.22	0.414124	
105	−376.4	−737.3	15.6	17.1	36070.11	0.571155	f?
106	− 30.3	+ 12.8	15.5	16.0			RRc
107	− 32.5	− 21.8	15.5	15.9			RRc
108	− 32.4	− 51.1	15.5	15.9			RRc
109	+ 12.7	− 31.3	15.5	16.1			RRc
110	+ 31.7	− 37.4	15.5	16.0			RRc
111	+ 41.7	− 0.7	15.3	16.2			RR
112	+ 55.5	+ 35.0	15.3	16.3			RR

New vars. 96-98 Izsák, 99 Mannino, 100-102 Notni and Oleak, 103-105 Tsoo Yu-hua, 106-112 Rosino. Three of the corona stars of Kurochkin (1963) are similar to cluster members.

Izsák, Budapest Mitt 28 (1952); Arp, AJ 60.1 (1955); Kholopov, VS 10.253 (1955); Grubissich, Asiago Contr 76 (1956); Mannino, Asiago Contr 74, 75 (1956); Izsák, Budapest Mitt 42.63 (1957); Nobili, Asiago Contr 81 (1957); Notni and Oleak, AN 284.49 (1958); Bachmann, AN 284.191 (1958); Mannino, Asiago Contr 110 (1959); Bronkalla, AN 285.181 (1960); Preston, ApJ 134.651 (1961); Yu-hua, Acta Astr Sinica 9.65 (1961); Fritze, AN 287.79 (1963); Kurochkin, VS 14.457 (1963); Makarova and Akimova, VS 15.350 (1965); Rosino, IBVS 327 (1969); Mironov, AC 637.1 (1971); Barlai, Priv comm (1972)

S55a, S57, S59, S61, A62, R62a, S62, P64, S64, L65, R65, St66, S67, C&S69, S69, S70

NGC 7089 (Messier 2) α 21^{h}30^m.9, δ −01°03′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+ 25.6	+ 79.4	13.2	14.8	26607.800	15.583	Sp F-G
2	− 45.8	+ 71.1	14.6	16.1	21454.971	0.527858	
3	+222.9	− 39.6	15.1	16.4	26921.952	0.6197006	
4	− 26.8	+ 31.5	15.2	16.6	26628.644	0.564247	
5	− 44.4	+ 2.1	13.2	14.9	26628.644	17.606	Sp F-G
6	+ 11.8	− 45.4	13.2	14.9	22162.928	19.295	Sp F-G
7	+153.0	−189.2	15.1	16.4	27274.901	0.594609	
8	− 66.9	− 56.8	15.1	16.4	27273.896	0.643677	
9	−173.2	−128.2	15.2	16.4	27274.901	0.609291	
10	+ 90.6	+ 38.8	15.2	16.4	27275.909	0.466910	Sp
11	+ 85	+ 8	12.5	14.0	31259.8	67.0	Sp F-G, Min
12	− 62	+ 43	15.1	16.5	26628.776	0.665616	
13	− 77	+ 73	15.1	16.4	26924.972	0.706616	
14	+ 83	− 68	15.4	16.4	20749.843	0.693785	
15	+ 80	− 76	15.7	16.4	26944.880	0.430152	
16	− 31	− 27	15.3	16.5	27275.950	0.655917	
17	+ 2	− 63	15.2	16.3	27274.901	0.636434	
18	−189	−707	15.95	16.85	40088.467	0.36226	P var
19	+235	−502	16.00	17.05	39089.384	0.319403	P var
20	+400	+ 74	16.00	16.75	37162.281	0.2863224	
21	+315	+208	15.75	16.85	39789.516	0.712178	P var

New vars. 18-21, Margoni and Stagni.

Arp, AJ 60.1 (1955); Arp and Wallerstein, AJ 61.272 (1956); Wallerstein, AJ **62**.168 (1957), ApJ **127**.583 (1958); Kulikov, VS 13.400 (1961); Mantegazza, Bologna Pubbl 8, 5 (1961); Preston, Krzeminski and Smak, ApJ **137**.401 (p) (1963); Margoni and Stagni, IBVS 239 (1967); Kukarkin, IBVS 253, 254 (1968); Poole, Master's Thesis, Toronto (1968); Demers, AJ 74.925 (1969); Margoni and Stagni, Asiago Contr 213 (1969); Kukarkin, IBVS 422 (1970); Voroshilov, AC 623.7 (1971); Eggen, ApJ **172**.639 (1972)

S55a, S57, S59, S61, R62a, S62, P64, S64, R65, S67, C&S69, S69, S70

NGC 7099 (Messier 30) α 21^{h}37^m.5, δ −23°25′

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks
1	+ 30.0	− 60.6	15.0	16.5	32060.525	0.743608	
2	+ 58.6	−126.2	14.92	16.04	32060.46	0.6535049	
3	− 96.7	− 39.6	14.91	16.06	32039.59	0.69632	
4	−339:	− 51:	16.1	[18	32450	9-10	UG
5							Terzan 1
6							Terzan 2
7							Terzan 3
8							Terzan 4
9							Terzan 5
10							Terzan 6
11							Terzan 7
12							Terzan 8

No.	x″	y″	Max.	Min.	Epoch	Period	Remarks

NGC 7099 (continued)

Variables of Terzan (1968) identified on print.

Rosino, Asiago Contr 117 (1961); Terzan, Haute Prov Publ 9, 24 (p) (1968); Dickens, Preprint (1972)

S55a, R57, S57, S59, R62a, S62, S64, R65, St66, S69, S70

Palomar 12 $\alpha\,21^h43^m.7$, $\delta\,-21°28'$

1	−97.4	+129.8	20.3	21.1			Zwicky, RR
2	−80.8	+136.8	20.3	21.5			RR, K&R
3	−51.2	+102.0	18.5	22			103a-D plate K&R

Zwicky, Morphological Astronomy, p. 205 (p) (1957); Kinman and Rosino, ASP 74.503 (p) (1962)
R61, S61, S64, S69

Palomar 13 $\alpha\,23^h04^m.2$, $\delta\,+12°28'$

1	− 32	+ 32	17.35	18.55	35759.505	0.538158	P var
2	+11	− 10	17.45	18.60	35782.381	0.597111	
3	− 8	+ 21	17.35	18.55	36455.770	0.578168	
4	+76	−300	17.55	18.65	35721.615	0.575340	

All four new variables, Rosino

Rosino, Asiago Contr 85 (p) (1957); Ciatti, Rosino and Sussi, Bamb Kl Veröff 4, 40.228 (1965)

R57, S59, R61, S61, S62, S67, S69

NGC 7492 $\alpha\,23^h05^m.7$, $\delta\,-15°54'$

1	+19.5	+ 96.0	17.07	17.67	37499.603	0.804873	
2	−19.5	+ 49.5	16.91	17.31		0.292045	
3	+30.0	−253.5	17.39	17.79		0.270998	
4	−36.5	−116.0	15.66	15.96		17.9	red

Three suspected variables, Barnes (1968), who found variables 2-4.

Kinman and Rosino, ASP 74.503 (1962); Barnes, Priv comm (1966), AJ 72.291 (1967), AJ 73.579 (1968)

S55a, S57, S59, S61, S62, S64, S67, S69, S70

INDEX OF ABBREVIATIONS USED IN REFERENCES, LISTED CHRONOLOGICALLY

S55a	Sawyer, H., Toronto Publ 2, 2: A Second Catalogue of Variable Stars in Globular Clusters, Table II, Summary of Variable Stars in 72 Globular Clusters (1955)
S55b	Sawyer, H., Toronto Publ 2, 2: Table I, Thirty-Four Globular Clusters Not Searched for Variables (1955)
R57	Rosino, L., Budapest Mitt 42: Problems of Variable Stars in Globular Clusters (1957)
S57	Sawyer Hogg, H., IAU Trans 9.548, Table 3a: Fifty-Nine Globular Clusters (1957)
S59	Sawyer Hogg, H., Handbuch der Physik, ed. S. Flügge (Berlin: Springer Verlag), p. 181: Star Clusters (1959)
R61	Rosino, L., IAU Trans 11B.300: Work Being Carried Out at the Asiago Observatory (1962)
S61	Sawyer Hogg, H., IAU Trans 11A.271: Report of Sub-Commission 27b, Variable Stars in Clusters (1962)
A62	Arp, H.C., Symposium on Stellar Evolution, 1960, La Plata (1962)
R62a	Rosino, L., Pad Com 29, Tables 3 and 4: Clusters Observed for Variables (1962)
R62b	Rosino, L., Pad Com 29, Table 1: Clusters Never Observed for Variables (1962)
R62c	Rosino, L., Pad Com 29, Table 2: Clusters Insufficiently Observed for Variables (1962)
S62	Sawyer Hogg, H., Bamb Kl Veröff 34.8: Numbers and Kinds of Variables in Globular Clusters (1962)
F&L63	Fourcade, C. R., and Laborde, J. R., La Plata Bol 6.111: Estrellas variables en cumulos globulares (1963)
P64	Preston, G., Ann Rev Astr Ap 2.23: The RR Lyrae Stars (1964)
S64	Sawyer Hogg, H., IAU Trans 12A.390: Variable Stars in Star Clusters (1965)
L65	Lohmann, W., AN 289.99: Perioden-Helligkeits-Beziehungen von RR Lyrae-Sternen in Kugelförmigen Sternhaufen (1965)
R65	Rosino, L., Bamb Kl Veröff 4.40.98: Characteristics and Absolute Magnitudes of the RR Lyrae Variables in Globular Clusters (1965)
FLA66	Fourcade, C. R., Laborde, J. R., and Albarracin, J., Atlas y Catalogo de estrellas variables en cumulos globulares al sur de $-29°$, Cordoba (1966)
St66	Stothers, R., AJ 71.943: The Ultraviolet Dwarfs: A New Class of Degenerate Stars (1966)
S67	Sawyer Hogg, H., IAU Trans 13A.555: Report of the Committee on Variable Stars in Clusters (1967)
C&S69	Coutts, C., and Sawyer Hogg, H., Toronto Publ 3.1: Period Changes of RR Lyrae Variables in the Globular Cluster Messier 5 (1969)
S69	Sawyer Hogg, H., Non-Periodic Phenomena in Variable Stars, ed. L. Detre, p.475: The Third Catalogue of Variable Stars in Globular Clusters (1969)
S70	Sawyer Hogg, H., IAU Trans 14A.291: Report of the Committee on Variable Stars in Clusters (1970)
F72	Feast, M., Preprint: Red Variables in Globular Clusters, in the Galactic Centre and in the Solar Neighbourhood (1972)

INDEX OF ABBREVIATIONS OF PUBLICATIONS

AAS Bull	Bulletin of the American Astronomical Society
AAVSO Abstr	Abstract of the American Association of Variable Star Observers
AC	Astronomical Circular. Bureau of Astronomical Information of the Academy of Sciences of USSR, Moscow
Acta Astr Sinica	Acta Astronomica Sinica
AG Mitt	Mitteilungen der Astronomischen Gesellschaft
AJ	The Astronomical Journal. Published by the American Astronomical Society
AN	Astronomische Nachrichten. Akademie-Verlag, Berlin
Ann Aph	Annales d'Astrophysique. Revue Internationale trimestrielle
Ann Rev Astr Ap	Annual Review of Astronomy and Astrophysics. Palo Alto
ApJ	The Astrophysical Journal, An International Review of Spectroscopy and Astronomical Physics, Chicago
ApJ Suppl	The Astrophysical Journal. Supplement Series
Asiago Contr	Contributi dell' Osservatorio Astrofisico dell' Università di Padova in Asiago
ASP	Publications of the Astronomical Society of the Pacific. San Francisco
Astr Abh Hoffmeister	Astronomische Abhandlungen Prof. Dr. C. Hoffmeister zum 70. Geburtstag Gewidmet. Leipzig
Astr and Ap	Astronomy and Astrophysics
BAC	Bulletin of the Astronomical Institutes of Czechoslovakia. Prague
Bamb Kl Veröff	Kleine Veröffentlichungen der Remeis-Sternwarte zu Bamberg
Bamb Veröff	Veröffentlichungen der Remeis-Sternwarte zu Bamberg
BAN	Bulletin of the Astronomical Institutes of the Netherlands. Haarlem
BAN Suppl	Bulletin of the Astronomical Institutes of the Netherlands. Supplement Series
Berg Abh	Abhandlungen aus der Hamburger Sternwarte. Hamburg-Bergedorf
Bologna Pubbl	Pubblicazzioni dell' Osservatorio astronomico universitario di Bologna
Budapest Mitt	Mitteilungen der Konkoly-Sternwarte zu Budapest-Svábhegy
Cordoba Repr	Observatorio de Cordoba. Reprint Series
HA	Annals of the Astronomical Observatory of Harvard College. Cambridge, USA
Haute Prov Publ	Publications de l'Observatoire de Haute Provence
HB	Bulletin of the Harvard College Observatory. Cambridge, USA
HC	Harvard College Observatory. Circular. Cambridge, USA
IAU Coll	International Astronomical Union, Colloquium
IAU Draft Reports	International Astronomical Union. Agenda and Draft Reports
IAU Trans	Transactions of the International Astronomical Union
IBVS	Information Bulletin on Variable Stars of Commission 27 of the International Astronomical Union. Budapest
Inf Bull So Hemis	Information Bulletin for the Southern Hemisphere. La Plata
JRASC	The Journal of the Royal Astronomical Society of Canada
JO	Journal des Observateurs. Marseilles
La Plata Bol	Asociacion Argentina de Astronomia. Boletin. La Plata
La Plata Symp	Symposium on Stellar Evolution, 1960. La Plata
Leaflet	Publications of the Astronomical Society of the Pacific. Leaflet. San Francisco
Leiden Ann	Annalen van de Sterrewacht te Leiden

Louv Publ	Publications du Laboratoire d'Astronomie et de Géodésie de l'Université de Louvain
Lyon Publ	Publications de l'Observatoire de Lyon. Série I. Astronomie
MN	Monthly Notices of the Royal Astronomical Society. London
Mt Wils Contr	Contributions from the Mount Wilson Observatory
MVS	Mitteilungen über veränderliche Sterne. Herausgegeben von der Sternwarte Sonneberg
NASA Tech Tr	National Aeronautics and Space Administration, USA. Technical Translation
Obs	The Observatory. Monthly Review of Astronomy. Oxford
Pad Com	Osservatorio Astronomico di Padova. Comunicazioni
Proc Astr Soc Aust	Proceedings of the Astronomical Society of Australia. Sydney
Pulk Mitt (Isw)	Mitteilungen (Istwestija) der russischen Hauptsternwarte zu Pulkovo
Quart JRAS	The Quarterly Journal of the Royal Astronomical Society
RAJ	Russian Astronomical Journal (until 1931). Astronomical Journal of Soviet Union
Royal Obs Ann	Royal Observatory Annals. Herstmonceux: Royal Greenwich Observatory
Royal Obs Bull	Royal Observatory Bulletins. Joint Publications of the Royal Greenwich Observatory, Herstmonceux; Royal Observatory, Cape of Good Hope
Rutherfurd Contr	Contributions from the Rutherfurd Observatory of Columbia University, New York
SAI	Memorie della Società Astronomica Italiana
Sky Tel	Sky and Telescope. Harvard College Observatory, Cambridge, USA
Sonn Veröff	Veröffentlichungen der Sternwarte zu Sonneberg
Soviet Astr AJ	Soviet Astronomy AJ. A translation of the Astronomical Journal of the Academy of Sciences of USSR. Published by the American Institute of Physics, Inc., New York
Spec Vat Ric	Specola Astronomica Vaticana. Richerche Astronomiche
Toronto Comm	Communications from the David Dunlap Observatory, University of Toronto
Toronto Publ	Publications of the David Dunlap Observatory, University of Toronto
UOC	Circular of the Union Observatory
VS	Variable Stars. Academy of Sciences of USSR, Moscow
VS Supp	Variable Stars. Supplement Series. Moscow
ZAp	Zeitschrift für Astrophysik. Berlin-Göttingen-Heidelberg

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THE SCULPTOR DWARF SPHEROIDAL GALAXY
I. DISCOVERY AND IDENTIFICATION OF VARIABLE STARS

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ABSTRACT

All 602 variable stars in the Sculptor dwarf spheroidal galaxy which have been discovered by the author and by previous investigators are identified. Positions are given in rectangular coordinates relative to the center of the distribution of the variables at RA (1950) = $0^h57^m44^s \pm 2^s$, Dec (1950) = $34^\circ 0' 23'' \pm 20''$.

For 64 variables preliminary periods are given.

The estimated total number of variables in the Sculptor galaxy is 1050 ± 80.

INTRODUCTION

The discovery of the dwarf galaxy in Sculptor by Harlow Shapley (1938 a) and the subsequent discovery of a similar object in Fornax (Shapley 1938 b) came when the interest of astronomers was focussed strongly on the significance of the sequence of galactic forms. They consequently attracted considerable interest.

In the Local Group ten Sculptor-type galaxies are now known. Table I includes the recently discovered dwarf spheroidal galaxy in Carina (Cannon, Hawarden and Tritton 1977).

TABLE I

SCULPTOR-TYPE GALAXIES

Name	l	b	Remarks
Fornax	237°	– 66°	Shapley (1938 a)
Sculptor	286	– 83	Shapley (1938 b)
Leo I	226	+ 49	Wilson (1955)
Leo II	219	+ 67	Wilson (1955)
Ursa Minor	103	+ 45	Wilson (1955)
Draco	86	+ 35	Wilson (1955)
Carina	260	– 22	Cannon et al (1977)
Andromeda I	122	– 25	van den Bergh (1972)
Andromeda II	129	– 29	van den Bergh (1972)
Andromeda III	119	– 26	van den Bergh (1972)

Nowadays the study of the dwarf spheroidal galaxies, especially of those nearest to us, contributes to investigations of stellar evolution and the evolution of the Local Group. (Norris and Zinn 1975, Lynden Bell 1976, Mathewson and Schwarz 1976). However knowledge about the stellar content and more specifically the numerous variable stars is still incomplete for these systems, as shown in review papers about the dwarf spheroidals by van den Bergh (1968, 1975), van Agt (1973) and Hodge (1971).

This report is a first contribution in an extended study of the variable stars in the dwarf spheroidal galaxy in Sculptor.

Distance And Dimensions

Shapley (1938 a) assumed correctly, on the basis of his scanty preliminary data, that the stellar population of the Sculptor galaxy was in many respects comparable with that of galactic globular clusters. On the assumption that the brightest stars in the Sculptor galaxy would have an absolute photographic magnitude of about $M_{pg} =\ 1.5$, Shapley (1938 a) derived a distance of 80 kpc.

Baade and Hubble (1939) observed the Sculptor galaxy with the 100-inch Mount Wilson telescope and were the first to discover, on a small number of plates, two variables thought to be W Virginis stars and 38 RR Lyrae variables, the latter visible close to the plate limit and only when they were near maximum luminosity.

On the basis of the observed mean maximum luminosity $m_{pg} = +19.12$ for the RR Lyrae stars, Baade and Hubble (1939) derived a distance of 84 kpc for the Sculptor galaxy. For these stars they assumed a semi-amplitude of 0.5 mag. and a median absolute magnitude of $M_{pg} = 0.0$ Later corrections to the sequence in SA 68 (Stebbins, Whitford, Johnson 1950) used by Baade and Hubble for the transfer to Sculptor were balanced by the shift of the median absolute photographic magnitude for RR Lyrae stars to fainter values so that Baade and Hubble's value of the distance (Hodge 1965) remains almost unaltered.

The two bright cepheids in Sculptor discovered by Baade and Hubble belong to a class of cepheids whose period-luminosity law differs from that of the cepheids in globular clusters (Baade and Swope 1961, van Agt 1973, van den Bergh 1975). Such anomalous cepheids with $P < 10$ days are also found in other dwarf spheroidal galaxies of the Local Group and are brighter than the BL Herculis variables of population II with P less than 10 days in galactic globular clusters. Provisional periods for these anomalous BL Her variables in the Sculptor cluster were determined by Miss Swope (Shapley 1939) and used by Shapley for a new distance determination of 76 kpc. In view of the uncertainties involved, this result is in agreement with his earlier estimate (Shapley, 1938 a) and with the value derived by Baade and Hubble (1939).

Hodge (1965) derived the first C – M diagram for the Sculptor dwarf spheroidal galaxy but it did not reach the horizontal branch. From the luminosities of the giant branch stars, the two anomalous BL Her stars, and the three RR Lyraes observed at maximum luminosity near the limit of his plates Hodge (1965) estimated a distance of 88 ± 7 kpc.

Kunkel and Demers (1977) recently derived a new distance of 78.3 kpc for Sculptor from the luminosity of the horizontal branch stars in the region of the variable gap in their C – M diagram. Their determination essentially confirms the results of the earlier investigators.

The apparent diameter was first determined by Shapley (1938 a) from star counts. Shapley's observations indicate an apparent radius of at least 40 arcmin but they do not exclude a radius of as much as 60 arcmin. From star counts Hodge (1965) derived a limiting radius of 53 arcmin, a value consistent with Shapley's result. At the distance of 78.3 kpc Hodge's angular radius yields a linear diameter of 2.4 kpc.

The variable stars reported on here extend up to distances from the center of the Sculptor galaxy of 60 – 70 arcmin. These values are in reasonable agreement with Shapley's conclusion that the Sculptor system might have a radius as large as 60 arcmin.

The dwarf spheroidal galaxies have many characteristics in common with globular clusters and at the same time show remarkable differences (van den Bergh 1975, van Agt 1973). The dwarf spheroidal galaxies are obviously considerably larger, but so far no transitional object with respect to linear dimension has been found.

OBSERVATIONS

Thackeray observed the Sculptor dwarf spheroidal galaxy during the observing seasons of 1948, 1949, 1950 and 1951 with the 74-inch Radcliffe telescope. His aim was specifically to investigate and discover variable stars in the central part of the dwarf galaxy. The surface density of the stars in the central region is sufficiently low to permit resolution of individual stars.

As a preliminary result Thackeray (1950) reported 237 variable stars and he derived provisional results on periods for 33 of them. He estimated the total number of variables to be 700. Our investigation of the variable stars in the Sculptor dwarf galaxy is a continuation of Thackeray's survey and for this purpose Thackeray kindly put his plates and reductions at our disposal. Considering both the number of variable stars marked by Thackeray in the central part of the galaxy and the dimensions of the system a bountiful harvest of variable stars was expected from the outset of our investigation.

In 1965 Sidney van den Bergh obtained a series of plates on the Sculptor system with the 48-inch Palomar Schmidt. In 1970 Christine Coutts obtained additional observations with the 24/36-inch Curtis Schmidt of the University of Michigan installed at Cerro Tololo, Chile. Helen Sawyer Hogg started the blinking of these plates at the David Dunlap Observatory. This material was turned over to me when I arrived at that Observatory on leave from the Department of Astronomy at the Nijmegen University, the Netherlands. I continued the series of Curtis Schmidt plates at Cerro Tololo in 1971. In addition Serge Demers put at our disposal the plates of Sculptor obtained by him with the same telescope in 1968 and 1969.

The field of the Curtis Schmidt telescope is well suited for observations of an extended object such as the Sculptor dwarf galaxy. On the plates taken with this telescope, which has a plate scale of $96''.6$/mm, inspection of the individual stars is possible even in the central region of this galaxy. This is due in part to the low surface density of stars and in part to the use of Kodak IIIa-J emulsion which partly overcomes the limit to linear resolution set by the small plate scale. To reach sufficiently low limiting magnitudes the plates are typically exposed for two hours. This leads to a reduction of the resolution in time of the brightness variations, especially for the variables with the shortest periods. For the c-type RR Lyrae with periods between 5 and 11 hours the exposures integrate a considerable part of the light curve. Obviously there is a reduced possibility of detection of the shortest period variables as a consequence of the long exposure time.

The photographic observations available to the author are listed in table II. They cover the period from 1938 to 1971. The earliest ones are the plates obtained by Baade (1939) and Hubble (1939). The large number of observations listed in table II provides a good time base for period determination.

TABLE II

GENERAL LIST OF PHOTOGRAPHIC OBSERVATIONS OF THE SCULPTOR DWARF SPHEROIDAL GALAXY.

Telescope	Observer	Year	Emulsion,Filter	Number of Plates	Scale of Plates	Exposure Time (min)
100 - inch	Baade, Hubble	1938	various	9	16″.2/mm	90 - 120
Mount Wilson			combinations			
	Baade	1945	103aE	1		106
	Baade	1946	103aE	1		90
74 - inch	Thackeray	1948	103aO none	1	22″.5/mm	typical exposure time
Radcliffe	Thackeray	1949	103aO none	43		60 min
	Thackeray	1949	103aD none	1		120 min
	Thackeray	1950	103aO none	34		
	Thackeray	1951	103aO none	7		
48 - inch	v.d. Bergh	1965	103aD WR 12	4	67″.5/mm	12 - 15
Palomar	v.d. Bergh	1965	103aO WR 47	2		10
	v.d. Bergh	1965	103aO GG 13	2		12
	v.d. Bergh	1965	103aE RG 1	1		45
	v.d. Bergh	1969	103aD WR 12	1		15
	v.d. Bergh	1969	IIIaJ WR 4	1		30
24/36 - inch	Demers	1968	IIaO GG 13	3	96″.6/mm	60
CTIO	Demers	1968	IIaD GG 14	3		120
	Demers	1969	IIIaJ GG 13	8		120
	Demers	1969	103aE NG 2	1		120
	Coutts	1970	IIIaJ GG 13	11		120
	Coutts	1971	IIaD GG 14	1		30
	van Agt	1971	IIIaJ GG 13	26		120
	van Agt	1971	IIaO GG 13	1		60
60 - inch	van Agt	1971	103aO GG 13	2	18″/mm	75
CTIO						

During the observing run of 1971 the author also obtained a small number of photographic transfers to the sequences set up in Kron 3 (Walker 1970) and in NGC 121 (Tifft 1963) to extend the sequence in the Sculptor dwarf galaxy that had been obtained by Hodge (1965) to fainter limits. Two such transfers were also obtained with the 60-inch telescope at Cerro Tololo and used for the same purpose (van Agt 1973). A comparison of the photoelectric sequence of Kunkel and Demers (1977) and preliminary results from the photographic transfers does not show any serious discrepancies.

Discovery And Identification

From among the Curtis Schmidt plates available at the end of 1970 and listed in table III, selection of pairs for blinking was made on the basis of time interval, plate quality and limiting magnitude (table IV). The plate combinations were all blinked on the Zeiss blink comparator of the David Dunlap Observatory. The work was carried out without reference to preceding variable star searches by Baade and Hubble (1939), Thackeray (1950) and Helen Sawyer Hogg (1970). In all, 521 stars were marked by the author as variable or as being suspected of brightness variations.

The 602 variable stars discovered both by previous investigators and the author are listed in table V. They are numbered in chronological order of discovery.

The variable stars numbered 1 through to 26 are those first found by Baade and Hubble (1939). Baade and Hubble identified (1939) only 10 variable stars out of the 40 they discovered. On an unpublished chart of the Sculptor system Baade identified

TABLE III
List Of The 1969-1970 Curtis Schmidt Plates.

CTIO Plate Nr.	Date	Exp.Time	Emulsion	Filter	Remarks
5084	Sept 18, 1969	120 min	103aE	NG 2	
5166	Oct 12, 1969	120	IIIaJ	GG 13	baked plate
5168	Oct 12, 1969	120	IIIaJ	GG 13	baked plate
5176	Oct 13, 1969	120	IIIaJ	GG 13	baked plate
5184	Oct 14, 1969	120	IIIaJ	GG 13	baked plate
5186	Oct 14, 1969	120	IIIaJ	GG 13	baked plate
5190	Oct 15, 1969	120	IIIaJ	GG 13	baked plate
5197	Oct 16, 1969	120	IIIaJ	GG 13	baked plate
5643	Dec 13, 1969	90	IIIaJ	GG 13	baked plate
7093	Aug 4, 1970	120	IIIaJ	GG 13	
7095	Aug 4, 1970	120	IIIaJ	GG 13	
7111	Aug 6, 1970	120	IIIaJ	GG 13	
7113	Aug 6, 1970	120	IIIaJ	GG 13	
7128	Aug 7, 1970	120	IIIaJ	GG 13	
7130	Aug 7, 1970	120	IIIaJ	GG 13	
7142	Aug 8, 1970	120	IIIaJ	GG 13	
7144	Aug 8, 1970	120	IIIaJ	GG 13	
7161	Aug 9, 1970	120	IIIaJ	GG 13	
7163	Aug 9, 1970	120	IIIaJ	GG 13	
7180	Aug 10, 1970	120	IIIaJ	GG 13	

TABLE IV
PLATE PAIRS FORMED FOR BLINKING
FROM THE 1969-1970 CURTIS SCHMIDT OBSERVATIONS.

Plate Pair Nr.	CTIO Plate Nr.	Time Interval
1	7093, 7180	$6^d.086$
2	7130, 7163	2 .001
3	7093, 7095	.312
4	5166, 5186	2 .126
5	5176, 5184	1 .019
6	7093, 7163	5 .097
7	5168, 7130	299 .097
8	5166, 7130	299 .232
9	5176, 7130	298 .202

16 more however. For the remaining variable stars reported by Baade and Hubble no identification could be traced.

The variable stars numbered 27 through 241 are the ones newly discovered by Thackeray (1950) on the plates obtained with the Radcliffe telescope. These did not include plates off-set from the center of the dwarf galaxy. Variable stars farther from the center than approximately 20 arcmin therefore remained undetected.

In the preliminary search for variables on the Curtis Schmidt plates Helen Sawyer Hogg discovered 49 new variable stars. These objects have been assigned the numbers 242 through to 290.

The remaining stars, numbered through to 603, are the new variable stars discovered by the author. The star number 474 was subsequently found not to be a variable star and consequently has been eliminated from table IV. The total number of variable stars listed in table IV is therefore 602.

Kunkel and Demers (1977) found from their photographic photometry that their star 213 shows widely discrepant magnitudes on both B and V plates. They suspected this star to be variable; it is identified by Kunkel and Demers (1977) in their figure 5 as Star V. On the Radcliffe plates the photographic image of this object is in general not compatible with star images of similar photographic density. On recently obtained photographic observations at the prime focus of the 3.6 meter telescope of the European Southern Observatory at La Silla, Chile, this object under good seeing conditions is resolved as a faint galaxy. Widely varying magnitudes can be expected if such an object is mistaken for stellar and measured on plates obtained under not identical seeing conditions.

The variable stars listed in table V are identified by their number on Plates I, II, III, IV, V and VI. On all these Plates, directions on the sky and the scale are indicated.

The stars marked with "f" in column 5 of table V are those farthest away from the center of the Sculptor galaxy and not within the area that is represented in plate VI.

CENTER

Counts have been made of all the variables listed in table V in strips 60″ wide placed over the galaxy in the directions of right ascension and declination. The maxima of the counts in the strips orientated in this way led to the adopted position for the center of the distribution of the variable stars at RA (1950) = $0^h57^m44^s \pm 2^s$, Dec (1950) = $-34°0'23'' \pm 20''$.

COORDINATES OF THE VARIABLES

The coordinates were calculated from plate positions determined with the measuring facility of the projecting blink-comparator of the Department of Astronomy of the University of Nijmegen, the Netherlands (van Agt, 1972). The plate constants were derived from standard coordinates using a plate-scale of $96\overset{''}{.}6$/mm.

The rectangular coordinates are given for each of the 602 stars in columns 2 and 3 of table V. These coordinates are quoted in seconds of arc and are relative to the adopted center of the distribution of the variable stars.

The accuracy in the x and y coordinates, corresponding respectively to right ascension and declination, is ± 4 arcsec.

COMPLETENESS

The total number of discoveries of variable stars in a series of plate comparisons and the average number of times that each variable was found have been used by van Gent (1933) to derive the probability *w* of discovering a variable star on each plate pair of the series and N, the total number of variable stars which can be expected to be present in the field investigated. In each of the nine intercomparisons, N was calculated by applying van Gent's method (van Gent, 1933, Plaut, 1965, Hoffmeister 1970). The results are given in table VI.

TABLE VI
THE DISCOVERY PROBABILITY AND EXPECTED NUMBER OF VARIABLE STARS.

Number of Intercomparisons	Discovery Probability w (van Gent 1933)	Total of Variables Expected N (van Gent 1933)
1	–	–
2	0.152	650
3	0.160	692
4	0.207	631
5	0.206	682
6	0.182	773
7	0.162	805
8	0.141	839
9	0.129	897

There is a tendency for the discovery probability w to decrease as more and more plate pairs are intercompared. Hoffmeister (1933) pointed out that this decrease indicates the existence of a dispersion in the discovery probability among the variable stars. This dispersion is not taken into account in van Gent's method, which is based on the assumption that the discovery probability for each variable in the field is the same on each plate pair. There are a number of parameters to which the discovery probability of a variable star can be related. The effects of the apparent brightness of the stars, the shape of the light curve and the range of the brightness variations have been investigated by a number of authors (Kviz 1956, Kiang 1962, Plaut 1953). Also variations in the quality of the plate pairs and changes in the attitude of the observer may cause variations. In a general way the decrease of the discovery probability can be explained by the fact that during the first intercomparisons those variables will be found which have large discovery probability and in later intercomparisons essentially those variables are left which have small discovery probability (Hoffmeister 1933). Of the variables discovered by Baade 92% were rediscovered. Of those found by Thackeray in his extensive survey of the central region, 71% were rediscovered.

Kviz (1959) and Kiang (1962) have pointed out that the net effect of not taking into account variations in the discovery probability is an overestimate of w and thereby an underestimate of N. Richter (1968) in an extension of van Gent's method found that for RR Lyrae variables the total number of variables N computed with van Gent's method should be increased by a factor of 1.2 when one takes into account systematic effects on the discovery probability. From a semi-empirical method Plaut (1966) derived essentially the same factor.

From the preliminary periods and the average median luminosities of the variables in Sculptor it is safe to conclude that most of the variables are RR Lyrae stars. In view of the limited data on the variable stars at this time it is not possible to analyse the blink statistics with either Richter's or Plaut's method. For the time being we therefore simply adopt Richter's factor of 1.2 for extrapolating the results of table VI to obtain a somewhat more realistic total number of variables in the dwarf galaxy of 1050, with an estimated mean error of 80. The low linear resolution of the Curtis Schmidt plates in combination with the increased surface density of stars in the central region of Sculptor reduces the discovery probability relative to the outer regions of the system. The somewhat lower completeness factor derived from the number of rediscoveries of Thackeray's variables is not in disagreement with our completeness arguments.

The RR Lyrae Stars

At the present stage of the reductions, preliminary results on the periods for some of the variable stars are reported. In column 4 of table V periods for 64 stars are given. These periods have been determined by Thackeray and his co-workers Jackson, Shuttleworth and Wesselink, all of whom took part at certain stages in the reductions, and by the author. In column 5 of table V initials indicate to whom each period determination should be attributed. The variable stars for which periods have been determined are located in the central region of the dwarf galaxy because so far only the Radcliffe observations have been used for this.

Among those with periods, 51 are ab-type RR Lyrae stars and 9 have c-type RR Lyrae star characteristics. Although it is expected that the shortest period c-type RR Lyrae are under-represented in the discoveries, due to the long exposure times of the observations, it is evident that c-type RR Lyrae stars in Sculptor are not as scarce as in the Draco dwarf galaxy where they number about 4% of the number of RR Lyrae stars, (Baade and Swope 1961). The frequency distribution of the periods of the RR Lyrae stars in the Sculptor galaxy is smooth, does not show double maxima and is in general very similar to the period-frequency diagram of the galactic globular cluster NGC 5272 (Messier 3), (van Agt 1973, Cacciari and Renzini 1976, Thackeray 1950).

The mean period of the 51 ab-type RR Lyrae stars is $P = 0^d.567$. The shortest period in this sample of ab-type RR Lyrae stars is $P = 0^d.482$ (V66) and the longest is $P = 0^d.836$ (V88).

The mean periods of the ab-type RR Lyrae stars in four dwarf spheroidal galaxies are listed in table VII together with the number of ab-type RR Lyrae stars from which each mean period was determined.

TABLE VII

MEAN PERIODS OF ab-TYPE RR LYRAE IN DWARF SPHEROIDAL GALAXIES

Name	$\overline{P}$	Number of ab-type
Sculptor	$0^d.567$	51
Draco	0 .611	126
Ursa Minor	0 .636	21
Leo II	0 .592	64

Evidently the distribution of the mean periods of ab-type RR Lyrae stars in dwarf spheroidal galaxies does not follow the concept of the two period-groups observed for the RR Lyrae stars in galactic globular clusters by van Agt and Oosterhoff (1959). The mean period for the long period group (group I) is $\overline{P} = 0^d.647 \pm 0.015$ and for the short period group (group II) is $\overline{P} = 0^d.549 \pm 0.010$.

THE ANOMALOUS BL HERCULIS STARS

The variable stars V25 (= Baade-Hubble A), V26 (= Baade-Hubble B), and V119 belong to the class of anomalous BL Her stars which also have been discovered in other dwarf spheroidal galaxies in the Local Group (Swope 1968, Baade and Swope 1961, van Agt 1967). Similar variable stars are probably present in the Small Magellanic Cloud (van Agt 1973, Graham 1975). Zinn and Dahn (1976) report that V19 in the galactic globular cluster NGC 5466 might well belong to the class of anomalous BL Her stars, if indeed this variable is a member of the cluster. The anomalous BL Her stars are brighter by approximately 0.5 – 1.0 m_{pg} at the same period than the cepheids in the galactic globular clusters (van Agt 1973, Baade and Swope 1961, van den Bergh 1975).

Kunkel and Demers (1977) recently determined the photometric properties of the Baade-Hubble variable stars A and B (V25 and V26). They are located in the C – M dia-

gram of the Sculptor dwarf galaxy about 1.4 mag above the horizontal branch and are about half a magnitude brighter than the population II cepheids in galactic globular clusters of the same period.

Plates obtained recently at the prime focus of the 3.6 meter telescope of the European Southern Observatory show that V92, formerly classified as an anomalous BL Her star (van Agt 1973), is an optical double. One component is variable, the other is a star of similar mean luminosity. When unresolved, such an object would appear to have a luminosity in the range of the anomalous BL Her stars.

On the basis of the presently available data Norris and Zinn (1975) and Demarque and Hirschfeld (1975) offer a hypothesis to explain the observed period-luminosity relation for the anomalous BL Her stars. They suggest that these stars belong to a younger population of stars than the majority in the same dwarf spheroidal galaxy, which itself was formed independently of and after the collapse of our galaxy. Renzini, Mengel and Sweigart (1977) suggest, however, that if higher masses are assumed for the anomalous BL Her stars, mass-transfer within binary systems in the dwarf spheroidal galaxies also is a hypothesis in agreement with the observational evidence.

Long-Period and Red-Irregular Variable Stars

V544 located at about 14 arcmin north of the center of the Sculptor dwarf galaxy is bright on Curtis Schmidt plates taken in August 1970, but faint on plates taken in the same month one year earlier. Eye estimates of the variable star on the Radcliffe plates, where the star is in an unfavorable position close to the plate border, show the variable going through a maximum in 1949. The time of rise to maximum and the time of decline to minimum is of the order of 120 days. A longer period of 150 days is possible.

V97 is identical to the extremely red star numbered 453 in the list of Hodge (1965) of stars measured for the C – M diagram. In his C – M diagram this variable star is located at B – V = 2.16 mag., toward the red of the brightest stars of the giant branch. Eye estimates indicate a range in luminosity of approximately 0.6 m_{pg}. V97 is not among the stars measured by Kunkel and Demers (1977).

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TABLE V
VARIABLE STARS IN THE SCULPTOR DWARF SPHEROIDAL GALAXY:
COORDINATES AND PRELIMINARY PERIODS.

NR	X″	Y″	Period	Remarks
1	− 455.	184.	$P = {}^{d}.532$	Th
2	− 413.	93.		
3	52.	410.		
4	− 250.	108.		
5	53.	72.	$P = {}^{d}.484$	Th, vA
6	− 91.	− 150.		
7	191.	161.	$P = {}^{d}.285$:	Th
8	26.	− 49.		
9	− 46.	− 211.		
10	43.	− 196.	$P = {}^{d}.515$	vA
11	46.	− 215.	$P = {}^{d}.561$	vA
12	251.	− 119.		
13	− 5.	640.	$P = {}^{d}.340$	Th
14	− 612.	− 95.		
15	− 239.	280.		
16	10.	416.		
17	− 310.	− 94.		
18	− 53.	139.	$P = {}^{d}.289$	vA
19	145.	290.	$P = {}^{d}.639$	Th
20	199.	53.		
21	155.	− 134.	$P = {}^{d}.588$	vA
22	− 52.	− 590.		
23	192.	− 440.	$P = {}^{d}.510$	Th
24	363.	− 282.		
25	− 94.	560.	$P = {}^{d}.925$	Baade A, Th, vA
26	193.	− 276.	$P = 1^{d}.35$	Baade B, Th, vA
27	1149.	− 102.		
28	1076.	183.		
29	897.	610.		
30	895.	600.		
31	778.	355.		
32	813.	− 456.		
33	728.	119.	$P = {}^{d}.343$	vA
34	702.	− 109.	$P = {}^{d}.662$	vA
35	699.	− 95.	$P = {}^{d}.526$	vA
36	683.	− 474.	$P = {}^{d}.624$	vA
37	582.	237.		
38	556.	268.	$P = {}^{d}.502$	vA
39	578.	− 84.	$P = {}^{d}.506$	vA
40	572.	− 548.		
41	512.	− 50.	$P = {}^{d}.547$	vA
42	503.	51.	$P = {}^{d}.596$	vA
43	495.	75.	$P = {}^{d}.617$	vA, J
44	501.	− 314.		
45	496.	− 519.		
46	453.	117.		

TABLE V (continued)

NR	X″	Y″	Period	Remarks
47	485.	– 483.	$P = {}^{d}.526$:	Th
48	472.	– 440.	$P = {}^{d}.565$	Th, vA
49	402.	263.		
50	401.	– 356.	$P = {}^{d}.545$	Th
51	387.	– 134.		
52	377.	– 354.		
53	327.	50.	$P = {}^{d}.660$	Th
54	360.	– 497.	$P = {}^{d}.640$	Th
55	326.	– 339.		
56	293.	129.	$P = {}^{d}.567$	Th
57	253.	596.	$P = {}^{d}.541$:	vA
58	250.	480.		
59	249.	– 61.		
60	217.	259.	$P = {}^{d}.593$	Th
61	198.	377.		
62	216.	66.		
63	236.	– 337.	$P = {}^{d}.542$	Th
64	185.	398.		
65	193.	239.		
66	166.	450.	$P = {}^{d}.482$	vA
67	145.	655.		
68	155.	368.	$P = {}^{d}.506$	J, Sh
69	164.	– 190.		
70	139.	53.	$P = {}^{d}.663$	Th
71	136.	46.	$P = {}^{d}.519$	Th
72	144.	– 31.	$P = {}^{d}.548$	Sh, W
73	112.	565.		
74	101.	159.	$P = {}^{d}.488$	vA
75	64.	46.	$P = {}^{d}.504$:	Sh, vA
76	56.	12.	$P = {}^{d}.500$	Th
77	12.	438.	$P = {}^{d}.533$	J
78	33.	– 27.	$P = {}^{d}.587$	Th, Sh, W
79	42.	– 157.		
80	73.	– 441.		
81	– 23.	693.	$P = {}^{d}.560$	Sh, vA
82	20.	– 158.	$P = {}^{d}.570$	Sh
83	– 18.	41.	$P = {}^{d}.531$	Sh
84	– 6.	– 239.		
85	– 22.	– 128.		
86	– 25.	– 247.		
87	– 42.	33.		
88	– 71.	237.	$P = {}^{d}.836$	vA
89	– 50.	– 231.		
90	– 23.	– 372.		
91	– 75.	92.	$P = {}^{d}.618$	Th, vA

TABLE V (continued)

NR	X″	Y″	Period	Remarks
92	– 89.	138.	$P = {}^{d}\!.503$	vA
93	– 97.	381.		
94	– 80.	– 186.		
95	– 84.	5.		
96	– 99.	7.		
97	– 102.	– 41.		red irr.
98	– 96.	– 232.		
99	– 112.	– 165.		
100	– 141.	105.		
101	– 152.	162.	$P = {}^{d}\!.487$	vA
102	– 172.	321.		
103	– 169.	292.		
104	– 214.	– 98.		
105	– 228.	39.		
106	410.	306.		
107	195.	183.	$P = {}^{d}\!.307$	Th
108	86.	– 108.		
109	1137.	176.		
110	– 206.	– 397.		
111	– 248.	– 80.		
112	– 232.	– 425.		
113	– 268.	– 69.		
114	– 333.	576.		
115	– 311.	– 7.		
116	– 315.	– 27.		
117	– 323.	– 302.		
118	– 371.	406.		
119	– 376.	191.	$P = 1^{d}\!.15$	bright, Th, vA
120	– 358.	– 246.		
121	– 408.	301.		
122	– 411.	30.		
123	– 402.	– 170.	$P = {}^{d}\!.566$	vA
124	– 385.	– 469.		
125	– 460.	– 249.	$P = {}^{d}\!.495$	vA
126	– 538.	343.		
127	– 508.	– 598.		
128	– 580.	– 345.		
129	– 614.	171.		
130	– 690.	413.		
131	– 687.	– 532.		
132	– 745.	118.		
133	– 761.	239.		
134	– 805.	– 466.		
135	– 895.	– 316.		
136	819.	354.		
137	749.	629.		

TABLE V (continued)

NR	X″	Y″	Period	Remarks
138	764.	48.	$P = {}^{d}.619$	vA
139	726.	− 17.		
140	722.	− 207.		
141	700.	31.		
142	585.	716.		
143	514.	462.		
144	535.	− 93.	$P = {}^{d}.350$	vA
145	558.	− 61.	$P = {}^{d}.523$	Sh, W
146	479.	− 157.		
147	452.	83.		
148	466.	− 262.		
149	487.	− 522.		
150	434.	− 239.		
151	421.	− 80.		
152	425.	− 123.		
153	411.	− 136.		
154	402.	− 83.		
155	376.	112.	$P = {}^{d}.550$:	Th
156	355.	97.	$P = {}^{d}.509$	Th
157	344.	133.	$P = {}^{d}.293$	Th
158	378.	− 588.		
159	320.	− 32.	$P = {}^{d}.672$	Th
160	319.	158.	$P = {}^{d}.515$	Th
161	343.	− 193.		
162	274.	394.		
163	240.	− 18.		
164	273.	− 283.		
165	166.	731.		
166	213.	− 14.		
167	212.	− 391.		
168	179.	− 54.		
169	151.	199.		
170	133.	162.		
171	136.	− 7.		
172	94.	521.		
173	232.	− 765.		
174	75.	445.		
175	115.	− 235.		
176	113.	− 315.		
177	70.	− 140.		
178	52.	− 32.		
179	45.	− 20.	$P = {}^{d}.715$	vA
180	− 10.	437.		
181	43.	− 121.		
182	− 66.	375.	$P = {}^{d}.360$	Th

TABLE V (continued)

NR	X''	Y''	Period	Remarks
183	– 25.	– 36.		
184	– 5.	– 700.		
185	– 48.	– 571.		
186	– 102.	239.		
187	– 126.	668.		
188	– 113.	282.		
189	– 110.	36.		
190	– 124.	47.		
191	– 139.	– 16.		
192	– 93.	– 676.		
193	– 167.	154.		
194	– 185.	415.		
195	– 179.	294.		
196	– 199.	533.		
197	– 192.	190.		
198	– 150.	– 492.		
199	– 220.	165.	$P = {}^{d}.573$	vA
200	– 236.	556.		
201	– 159.	– 645.		
202	– 224.	– 301.		
203	– 242.	– 176.		
204	– 228.	– 526.		
205	– 357.	494.		
206	– 337.	38.		
207	– 386.	– 15.		
208	– 371.	– 579.		
209	– 423.	16.		
210	– 390.	– 536.		
211	– 459.	72.		
212	– 489.	– 105.		
213	– 481.	– 762.		
214	– 569.	349.		
215	– 633.	369.		
216	– 669.	145.		
217	– 665.	– 24.		
218	– 731.	– 26.		
219	– 727.	– 284.		
220	– 766.	– 612.		
221	822.	– 426.		
222	– 312.	– 109.		
223	253.	– 327.		
224	287.	225.		
225	469.	– 151.		
226	132.	174.		
227	– 689.	89.		
228	535.	– 240.		

TABLE V (continued)

NR	X″	Y″	Period	Remarks
229	− 77.	− 135.		
230	− 568.	− 45.		
231	− 79.	66.		
232	− 549.	21.		
233	− 23.	345.		
234	− 223.	− 173.	$P = {}^{d}.642$	vA
235	524.	− 47.	$P = {}^{d}.379$:	vA
236	− 50.	132.		
237	− 69.	257.		
238	− 583.	187.		
239	176.	448.		
240	− 759.	229.		
241	− 32.	241.		
242	− 321.	1224.		
243	212.	372.		
244	134.	1036.		
245	193.	1096.		
246	− 909.	− 945.		
247	− 909.	− 525.		
248	− 779.	− 448.		
249	916.	− 517.		
250	− 990.	− 10.		
251	− 799.	201.		
252	− 1010.	583.		
253	− 876.	766.		
254	− 865.	803.		
255	− 1015.	810.		
256	− 702.	1190.		
257	− 515.	− 256.		
258	− 644.	− 289.		
259	− 484.	472.		
260	− 715.	− 197.		
261	− 59.	− 1228.		
262	− 464.	444.		
263	− 78.	529.		
264	− 128.	− 4.		
265	29.	− 706.		
266	36.	− 691.		
267	288.	− 724.		
268	106.	− 206.		
269	11.	315.		
270	843.	− 561.		
271	654.	− 480.		
272	392.	757.		
273	510.	785.		
274	715.	570.		

TABLE V (continued)

NR	X″	Y″	Period	Remarks
275	1011.	408.		
276	948.	− 169.		
277	813.	− 543.		
278	1038.	− 827.		
279	959.	6.		
280	747.	337.		
281	883.	404.		
282	997.	521.		
283	720.	648.		
284	934.	676.		
285	772.	1111.		
286	928.	988.		
287	781.	410.		
288	1130.	− 474.		
289	1308.	− 961.		
290	− 385.	1039.		
291	204.	− 389.		
292	− 45.	130.		
293	− 106.	− 78.		
294	− 755.	− 20.		
295	− 494.	− 250.		
296	− 569.	180.		
297	− 847.	188.		
298	− 889.	75.		
299	− 290.	225.		
300	− 764.	589.		
301	− 1570.	− 356.		
302	− 1556.	84.		
303	− 1085.	13.		
304	− 2881.	277.		
305	1851.	− 16.		uncertain var.
306	1700.	23.		
307	2504.	98.		
308	3173.	1093.		
309	53.	− 408.		
310	− 2.	− 485.		
311	− 489.	− 375.		
312	355.	12.		
313	225.	148.		
314	832.	192.		
315	944.	29.		
316	− 446.	261.		
317	− 374.	838.		
318	292.	578.		
319	575.	578.		
320	− 204.	962.		

TABLE V (continued)

NR	X″	Y″	Period	Remarks
321	439.	1158.		
322	1463.	875.		
323	1769.	1117.		
324	3063.	921.		
325	564.	– 942.		
326	– 1297.	– 1052.		
327	– 2089.	– 2059.		
328	1690.	– 543.		
329	155.	– 789.		
330	– 250.	– 529.		
331	– 291.	– 526.		
332	– 312.	– 899.		
333	– 683.	– 790.		
334	– 1267.	– 457.		
335	– 1893.	– 209.		
336	– 1067.	– 576.		
337	237.	– 1206.		
338	– 3217.	– 2130.		
339	– 581.	– 2871.		
340	982.	115.		
341	1283.	275.		
342	408.	– 206.		
343	– 288.	1295.		
344	– 152.	2070.		
345	376.	– 451.		
346	79.	30.		
347	– 398.	265.		
348	– 1627.	205.		
349	– 841.	– 329.		
350	– 828.	– 155.		
351	263.	– 256.		
352	1116.	– 149.		
353	907.	– 1010.		
354	798.	918.		
355	600.	1320.		
356	– 653.	1660.		
357	– 574.	1554.		
358	1657.	1990.		
359	482.	1958.		uncertain var.
360	– 957.	1952.		
361	– 1809.	1286.		
362	– 1789.	1210.		
363	– 1568.	369.		
364	386.	– 59.		
365	228.	– 243.		
366	79.	– 255.		

TABLE V (continued)

NR	X″	Y″	Period	Remarks
367	– 62.	– 378.		
368	51.	– 131.		
369	– 362.	– 432.		
370	92.	– 552.		
371	– 507.	– 434.		
372	– 866.	– 446.		
373	– 1354.	– 790.		
374	– 1731.	– 1078.		
375	– 2537.	– 2028.		
376	– 15.	– 1109.		
377	1905.	– 1378.		
378	– 638.	– 2047.		
379	– 2102.	– 3723.		
380	421.	476.		
381	97.	1.		
382	– 50.	– 233.		
383	– 13.	118.		
384	– 6.	– 164.		
385	134.	– 229.		
386	6.	– 299.		
387	– 299.	– 70.		
388	– 318.	60.		
389	– 578.	39.		
390	– 423.	– 265.		
391	– 208.	1228.		
392	– 288.	653.		
393	– 847.	919.		
394	352.	679.		
395	618.	598.		
396	357.	372.		
397	– 1998.	159.		
398	– 1659.	– 6.		
399	– 1139.	262.		
400	– 829.	– 478.		
401	– 717.	494.		uncertain var.
402	– 567.	559.		uncertain var.
403	– 484.	195.		
404	– 647.	– 142.		
405	– 593.	– 104.		
406	70.	75.		
407	34.	– 3.		
408	319.	69.		
409	377.	142.		
410	629.	– 242.		uncertain var.
411	734.	32.		
412	1859.	23.		uncertain var.

TABLE V (continued)

NR	X″	Y″	Period	Remarks
413	3006.	192.		
414	1008.	− 227.		
415	837.	43.		
416	− 177.	− 744.		
417	430.	− 618.		
418	509.	− 828.		
419	55.	− 606.		
420	761.	− 622.		
421	− 942.	− 994.		
422	− 470.	− 952.		
423	634.	− 882.		
424	623.	− 901.		
425	778.	− 150.		
426	− 88.	− 442.		
427	− 10.	27.		
428	− 153.	− 1111.		
429	− 165.	− 949.		
430	− 888.	− 437.		
431	− 1078.	− 264.		
432	825.	− 1093.		
433	2033.	244.		
434	107.	− 440.		
435	543.	381.		
436	173.	− 380.		
437	1090.	− 157.		
438	1151.	− 164.		
439	166.	− 682.		
440	43.	− 616.		
441	− 235.	− 613.		
442	1020.	− 1067.		
443	− 2229.	− 1141.		
444	3272.	− 1258.		
445	2184.	− 1913.		
446	− 7.	208.		
447	65.	218.		
448	39.	154.		
449	− 49.	311.		
450	− 625.	− 78.		
451	− 355.	11.		
452	− 95.	− 114.		
453	− 69.	54.		
454	− 58.	11.		
455	− 982.	− 27.		
456	− 1322.	305.		
457	1047.	615.		
458	418.	517.		

TABLE V (continued)

NR	X″	Y″	Period	Remarks
459	– 591.	126.		
460	– 909.	236.		
461	– 3516.	– 142.		
462	– 13.	478.		
463	1056.	487.		
464	798.	491.		
465	164.	859.		
466	198.	239.		
467	366.	39.		
468	468.	– 124.		
469	274.	– 77.		
470	– 94.	935.		
471	– 91.	1401.		
472	– 69.	1245.		
473	– 555.	1216.		
475	– 308.	123.		
476	– 491.	240.		
477	– 366.	– 304.		
478	381.	– 1042.		
479	– 1838.	– 2335.		
480	1479.	– 1233.		
481	– 784.	– 20.		
482	– 1519.	576.		
483	– 1823.	634.		
484	– 1459.	– 828.		
485	– 861.	– 951.		
486	1635.	91.		
487	1178.	– 260.		
488	1115.	– 255.		
489	978.	303.		
490	540.	260.		
491	486.	215.		
492	– 82.	– 410.		
493	205.	– 413.		
494	– 364.	– 299.		
495	– 674.	– 539.		
496	– 857.	– 557.		
497	– 307.	1019.		
498	– 102.	31.		
499	– 482.	– 11.		
500	– 410.	434.		
501	– 725.	– 405.		
502	– 780.	– 358.		
503	– 2561.	– 898.		
504	– 480.	562.		

TABLE V (continued)

NR	X″	Y″	Period	Remarks
505	931.	964.		
506	775.	719.		
507	– 56.	86.		
508	– 246.	– 56.		
509	– 366.	56.		
510	– 602.	– 198.		
511	576.	– 790.		
512	733.	– 243.		
513	611.	– 1911.		
514	707.	– 2389.		
515	– 587.	– 115.		
516	– 659.	– 364.		
517	– 544.	– 339.		
518	– 220.	– 50.		
519	– 395.	50.		
520	– 1457.	– 250.		
521	– 1376.	122.		
522	– 355.	– 424.		
523	– 115.	– 370.		
524	103.	– 395.		
525	277.	– 688.		
526	165.	– 429.		
527	1033.	457.		
528	3627.	1661.		
529	1683.	2025.		
530	1941.	1166.		
531	1165.	918.		
532	449.	873.		
533	– 271.	658.		
534	– 958.	689.		
535	– 1585.	818.		
536	1441.	– 249.		
537	1637.	– 129.		
538	1313.	32.		
539	– 238.	– 246.		
540	603.	– 318.		
541	951.	– 809.		
542	924.	316.		
543	– 456.	1068.		
544	– 111.	866.		LP
545	280.	435.		
546	– 1472.	– 879.		
547	– 990.	– 1218.		
548	– 717.	– 562.		
549	– 311.	– 75.		
550	– 87.	– 708.		

TABLE V (continued)

NR	X″	Y″	Period	Remarks
551	48.	– 971.		
552	– 288.	– 178.		
553	2638.	– 202.		
554	– 407.	816.		
555	– 1764.	254.		
556	– 975.	– 5.		
557	283.	138.		
558	306.	– 455.		
559	– 1401.	215.		
560	– 1788.	9110.		f
561	– 7014.	4894.		f
562	– 402.	4658.		f
563	– 1822.	4005.		f
564	1867.	4050.		f
565	– 3900.	2613.		
566	4722.	2231.		
567	– 868.	2039.		
568	– 637.	760.		
569	3623.	1934.		
570	531.	740.		
571	1865.	908.		
572	4150.	1068.		
573	– 2626.	873.		
574	434.	25.		
575	352.	302.		
576	– 24.	372.		
577	2032.	– 70.		
578	3547.	241.		
579	– 2587.	– 974.		
580	– 1820.	– 668.		
581	– 1310.	– 386.		
582	91.	– 902.		
583	547.	– 32.		
584	2783.	– 234.		
585	1155.	– 570.		
586	– 3030.	– 1954.		
587	2895.	– 2235.		
588	544.	– 3283.		
589	– 866.	– 4293.		f
590	2839.	– 3990.		f
591	4291.	– 5002.		f
592	– 2817.	– 5650.		f
593	– 921.	– 6133.		f
594	7258.	– 7025.		f
595	3721.	– 6907.		
596	– 1708.	521.		

TABLE V (continued)

NR	X″	Y″	Period	Remarks
597	− 295.	382.		
598	− 1486.	− 809.		
599	1161.	− 38.		
600	− 131.	1030.		
601	− 4691.	9683.		f
602	274.	113.		
603	− 2016.	1127.		

PLATE I

Identification of the variable stars in the central region of the sculptor dwarf spheroidal galaxy. The scale (60″) is indicated in the upper right hand corner.

PLATE II
Identification of the variable stars in the NW quadrant. The scale (120″) is indicated.

PLATE III
Identification of the variable stars in the NE quadrant.

PLATE IV
Identification of the variable stars in the SE quadrant.

PLATE V
Identification of the variable stars in the SW quadrant.

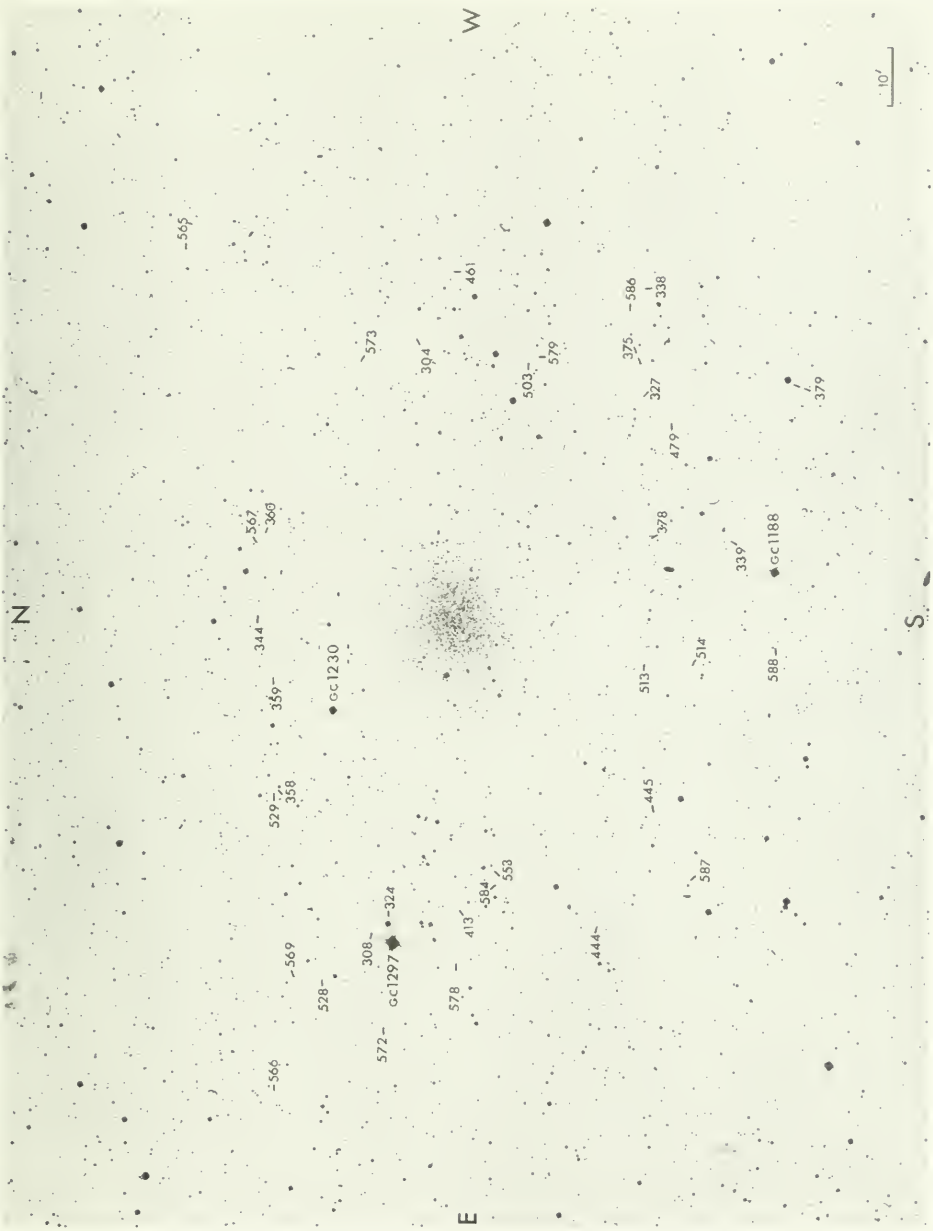

PLATE VI

Identification of the majority of the variable stars in the outer regions of the Sculptor dwarf galaxy. The scale (10 arcmin) is indicated.